PATENT ABSTRACTS OF JAPAN

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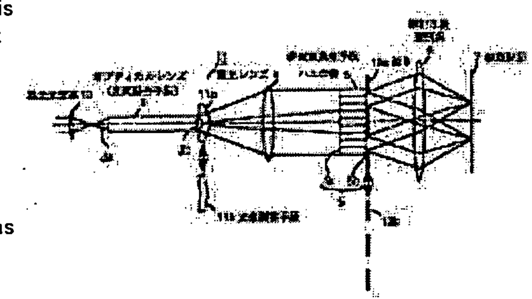
(54) LIGHTING DEVICE AND ALIGNER USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To make switching between normal lighting method and deformed lighting method easier while allowing an irradiated surface to be lit evenly up high lighting efficiency, by providing an optical flux adjusting means near an out-going surface of an optical flux mixing means, for allowing adjustment of light quantity distribution on an incidence surface of a plurality of optical-flux generating means.
SOLUTION: An optical flux from an out-going angle preserving optical element is made to generate a condensed point by a condensing optical system 10, then it is made incident on an incidence surface 3a of an optical pipe (optical flux mixing means) 3. Near an out-going surface 3b of an optical pipe 2, optical flux adjusting means 11a and 11b which can be detached/attached for replacement are provided, for regulating the optical flux distribution out-going from the optical pipe 3. The optical flux adjusting means 11a forms such effective light source as of zone of larger outside diameter on an incidence surface 5a of a plurality of optical-flux generating means 5 while the optical flux adjusting means 11b that of smaller outside diameter. A condenser lens 4 makes the light flags from a light flux adjusting means 11 condensed on the incidence surface 5a of the plurality of optical-flux generating means 5 comprising a fly-eye lens.



CLAIMS

[Claim(s)]

[Claim 1]In a lighting system characterized by comprising the following, a light flux adjustment device is provided near the emission face of this light flux mixing means, and luminous energy distribution in an entrance plane of this multi luminous flux generator is constituted so that adjustment is possible. .

A light source.

A condensing optical system which condenses light flux from this light source.

A light flux mixing means which mixes and ejects light flux from this condensing optical system.

A multi luminous flux generator which generates much partial luminous flux using an outgoing beam from this light flux mixing means, and an irradiation means which irradiates with an irradiated plane where light flux from this multi luminous flux generator is piled up.

[Claim 2]Claim 1 having set up an optical system arranged between said light flux mixing means and said multi luminous flux generator, and become approximately conjugate according to this optical system about an emission face of this light flux mixing means, and an entrance plane of this multi luminous flux generator, or 2 lighting systems.

[Claim 3]Claim 1, wherein said light flux mixing means has an optical pipe, or 2 lighting systems.

[Claim 4]A lighting system of Claim 1 to which, as for said light flux adjustment device, the entrance plane side is characterized by consisting of an optical member in which the emission face concave surface side has a convex conic surface, 2, or 3.

[Claim 5]A lighting system of Claim 1 to which, as for said light flux adjustment device, the entrance plane side is characterized by consisting of an optical member in which the emission face concave surface side has a convex polygonal-pyramid side, 2, or 3.

[Claim 6]A lighting system of Claim 1, wherein said light flux adjustment device consists of an optical member in which the entrance plane side has the flat surface for which the emission face concave surface side cut a vertex of a convex polygonal-pyramid side in respect of being level to an optic axis, 2, or 3.

[Claim 7]A lighting system of Claim 1, wherein said light flux adjustment device has two diffraction optical elements which have zona-orbicularis-like phase distribution, 2, or 3.

[Claim 8]Said light flux adjustment device has the substrate which provided a diffraction optical element in the whole surface, The surface integral rate of this diffraction optical element is carried out to many fields on this whole surface, and a diffraction optical element of each field is formed from a linear shape pattern, A lighting system of Claim 1 the diffraction directions of light flux by a diffraction optical element of each field differing mutually, and forming strong light intensity distribution in a discrete position on said multi luminous flux generator [else], 2, or 3.

[Claim 9]A lighting system of Claims 1-8 having provided two or more light flux adjustment devices in which it was made for luminous energy distribution on an entrance plane of said multi luminous flux generator to differ, and having set up one of light flux adjustment devices of this plurality selectable into an optical path given in any 1 clause.

[Claim 10]A lighting system of Claims 1-9, wherein said multi luminous flux generator has an eye of a fly given in any 1 clause.

[Claim 11]A lighting system of Claims 1-10 having established a diaphragm from which aperture shape differs according to a kind of said light flux adjustment device exchangeable near the emission face of said multi luminous flux generator given in any 1 clause.

[Claim 12]A projection aligner currently carrying out projection exposure of the pattern on an object face established in an irradiated plane using a lighting system of 11 given in any 1 clause from Claim 1 to an exposure substrate according to a projection optical system.

[Claim 13]A pattern on an object face established in an irradiated plane using a lighting system of 11 given in any 1 clause from Claim 1 according to a projection optical system to an exposure substrate. A projection aligner synchronizing this object and both sides of this exposure substrate with an optic axis and a perpendicular direction of this projection optical system with a velocity ratio made equivalent to projecting magnification of this projection optical system, scanning them, and exposing them.

[Claim 14]A manufacturing method of a device carrying out the development of this exposure substrate, and manufacturing a device after carrying out projection exposure of the pattern on an object face on an exposure substrate according to a projection optical system using Claim 12 or a projection aligner of 13.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]Specifically in the manufacturing installation of devices, such as a semiconductor device, about the manufacturing method of the projection aligner and device with which this invention used a lighting system and it, For example, it illuminates the pattern on a reticle side appropriately and high resolution was acquired easily, it is suitable for the projection aligner of a step and repeat system or a step and scanning method.
[0002]
[Description of the Prior Art]In order to attain high-resolving-power-ization, removal of the illumination unevenness in a mask surface (reticle side) is strongly demanded of the lighting system generally used for the exposure device for device fabrication, such as a semiconductor device. The lighting system which aimed at improvement in condensing efficiency has proposed these people as this demand in JP,H1-000913,A.
[0003]Drawing 34 is an important section schematic view of the lighting system proposed in the gazette.
[0004]One in a figure is a light source and consists of extra-high pressure mercury lamps etc. 2 consists of elliptical mirrors etc. by a condensing means, and the light source 1 is arranged near the 1st focus of this elliptical mirror 2. 3 comprises the optical pipe of prescribed shape by a light flux mixing means, and, as for the entrance plane 3a of this optical pipe 3, near [the 2nd focus] arrangement of the elliptical mirror 2 is carried out. It is an eye of the fly whose 4 is a condenser and whose 5 is a multi luminous flux generator, and the condenser 4 is set up so that the emitting end 3b of the optical pipe 3 and the entrance plane 5a of the eye 5 of a fly may serve as abbreviated conjugation relation. It is determined that many optical constants of the condenser 4 carry out image formation of the emitting end 3b to the entrance plane 5a for desired magnification in that case.
[0005]6 consists of composition which contains a condenser lens by an irradiation means, and is irradiating with the irradiated plane 7 where a mask, a reticle side, etc. are set up using the light flux from the emission face 5b of the eye 5 of a fly.
[0006]The Koehler illumination system which abbreviated-coincides the front side focus of the condensing means 6, and abbreviated-coincides with the irradiated plane 7 and the backside focus of the condensing means 6 the condensing point (backside focus) of the element lens which constitutes the eye 5 of a fly in that case is constituted.
[0007]Using the multiple echo by a medial surface, the optical pipe which is the light flux mixing means 3 forms many ** or the condensing point of a fruit from one light flux, and shows the principle to drawing 35 - 37.
[0008]For example, in the hollow which has a square cross section as shows drawing 37 an optical pipe, it is assumed that it comprises a component which carries out internal reflection.
[0009]Drawing 35 expresses signs that the condensing point of ** is formed of the condensed light bunch which has the light source image S0 in the front side of the entrance plane 301a of the optical pipe 3 in the section in alignment with an optic axis.
[0010]The light flux which is not once reflected among the light flux which enters from the light source image S0 on the upper part side 301c and 301 d of lower part sides is emitted from the projection surface 301b as it is.
[0011]The light flux reflected once only on the upper part side 301c, The light flux which is emitted so that it may be supplied about the upper part side 301c from the condensing point S0 and the condensing point S1 of conjugate ****, and is reflected once on 301 d of lower part sides is emitted so that it may be supplied about 301 d of lower part sides from the condensing point S0 and the condensing point S-1 of conjugate ****.
[0012]After emitting the light flux reflected on the upper part side 301c like the following after reflecting on 301 d of lower part sides so that it may be supplied from the condensing point S0, and reflecting on the upper part side 301c, the light flux reflected on 301 d of lower part sides is emitted so that it may be supplied from the condensing point S2.
[0013]Therefore, the light flux with the light source image S0 which enters into this optical pipe is emitted as substantially supplied by the reflection of 1 time or multiple times in the side from many light source images.
[0014]As a result, the emission face 301b comes to be illuminated by the light flux from many condensing points when the situation of the condensing point seen from the emission face by reflection in each side was distributed in the shape of a lattice like drawing 36, and the substantial surface light source is formed in the field S in which ******** of these large number is formed.
[0015]therefore, the emitting end 301b of the optical pipe 3 -- abbreviated -- uniform illuminance distribution can be acquired.
[0016]Although the uniform degree becomes settled by the reflecting times of the light flux within the optical pipe 3, detailed explanation is omitted here.
[0017]The eye 5 of a fly consists of an array of two or more microlenses, and the emission face 5b forms the secondary surface of light source.
[0018]as already explained, the emission face 301b of the optical pipe 3 and the entrance plane 5a of the eye 5 of a fly are connected to approximately conjugate -- the emission face 301b of the optical pipe 3 -- already -- abbreviated, although uniform illuminance distribution is formed, Still more uniform illuminance distribution is attained on an irradiated plane by entering it in the eye 5 of a fly and irradiating with the irradiated plane 7 with Koehler illumination by the irradiation means 6.
[0019]By the way, the resolution as which a projection aligner is required is also increasing with improvement in the degree of location

of the latest semiconductor device every year. In order to raise resolution, research and development in various methods, such as short wavelength formation of a light source, adoption of a phase shift method, and adoption of a deformation illumination method, is done, and it is not necessary to add a large change and, and the deformation illumination method has especially the advantage that change of the conventional mask pattern is unnecessary, to equipment conventionally.

[0020]as the typical example of a deformation illumination method -- the pupil of a projection optical system of an illumination-light study system -- abbreviated -- when light flux passes in a conjugate field, the passing position of light flux with the method of making it call what is called quadrupole Lighting Sub-Division restricted to four places estranged from the optic axis. Especially two of the methods called what is called ring pair Lighting Sub-Division with which the passing position of light flux is restricted an optic axis and in the shape of [concentric] zona orbicularis in the field of the aforementioned illumination-light study system are common.

[0021]Although quadrupole Lighting Sub-Division has a remarkable effect of the improvement in resolution, and increase of the depth of focus about especially the pattern that comprises vertical and horizontal lines, about the pattern which consists of a line of an oblique direction, there is a fault usually worsening rather than Lighting Sub-Division which does not carry out deformation illumination rather.

[0022]On the other hand, zona-orbicularis Lighting Sub-Division has the feature for which it does not depend in the direction of a pattern, although the effect of the improvement in resolution and depth-of-focus increase is not more remarkable than a quadrupole.

[0023]As a lighting system using a deformation illumination method, by JP,H5-251308,A, the zona-orbicularis-like luminous flux transforming means which changes a parallel beam into zona-orbicularis-like light flux is established between a light source means and an integrator, and oblique illumination of the illuminated face is carried out uniformly.

[0024]In JP,H5-283317,A or JP,H6-204114,A, the optical element which can be inserted and detached and which makes a prescribed direction deflect an incoming beam between an elliptic mirror and an optical integrator is arranged, the light intensity distribution of the entrance plane of an optical integrator is changed, and the irradiated plane is illuminated.

[0025]

[Problem to be solved by the invention]This invention improves the lighting system mentioned above, and the change of illumination and a deformation illumination method is usually easy for it, And an irradiated plane can be uniformly illuminated by high illumination efficiency, and it aims at offer of the manufacturing method of the lighting system which can manufacture easily the device which is the degree of high integration and the projection aligner using it, and a device.

[0026]

[Means for solving problem]The condensing optical system in which the lighting system of this invention condenses the light flux from a light source (1-1) and this light source, The light flux mixing means which mixes and ejects the light flux from this condensing optical system, and the multi luminous flux generator which generates much partial luminous flux using the outgoing beam from this light flux mixing means, It is characterized by providing a light flux adjustment device near the emission face of this light flux mixing means, and constituting the luminous energy distribution in the entrance plane of this multi luminous flux generator in the lighting system which has an irradiation means which irradiates with an irradiated plane, so that adjustment is possible where the light flux from this multi luminous flux generator is piled up.

[0027]In particular, the optical system is arranged between said (1-1-1) light flux mixing means and said multi luminous flux generator, and set up to become approximately conjugate according to this optical system about the emission face of this light flux mixing means, and the entrance plane of this multi luminous flux generator.

(1-1-2) Said light flux mixing means should have an optical pipe.

(1-1-3) Said light flux adjustment device should consist of an optical member in which the emission face concave surface side has a convex conic surface in the entrance plane side.

(1-1-4) Said light flux adjustment device should consist of an optical member in which the emission face concave surface side has a convex polygonal-pyramid side in the entrance plane side.

(1-1-5) Said light flux adjustment device should consist of an optical member in which the entrance plane side has the flat surface for which the emission face concave surface side cut the vertex of the convex polygonal-pyramid side in respect of being level to an optic axis.

(1-1-6) Said light flux adjustment device should have two diffraction optical elements which have zona-orbicularis-like phase distribution.

(1-1-7) Said light flux adjustment device has the substrate which provided the diffraction optical element in the whole surface, The surface integral rate of this diffraction optical element is carried out to many fields on this whole surface, and the diffraction optical element of each field is formed from the linear shape pattern, The diffraction directions of the light flux by the diffraction optical element of each field differ mutually, and form strong light intensity distribution in the discrete position on said multi luminous flux generator [else].

(1-1-8) Provide two or more light flux adjustment devices in which it was made for the luminous energy distribution on the entrance plane of said multi luminous flux generator to differ, and set up one of the light flux adjustment devices of this plurality selectable into an optical path.

(1-1-9) Said multi luminous flux generator should have an eye of a fly.

(1-1-10) It is characterized by having established the diaphragm from which aperture shape differs according to the kind of said light flux adjustment device exchangeable near the emission face of said multi luminous flux generator etc.

[0028]It is characterized by the projection aligner of this invention carrying out projection exposure of the pattern on the object face established in the irradiated plane (2-1) to the exposure substrate according to the projection optical system using the lighting system of composition (1-1).

(2-2) It is characterized by synchronizing the pattern on the object face established in the irradiated plane with the velocity ratio which made this object and the both sides of this exposure substrate correspond to the projecting magnification of this projection optical system to the optic axis and perpendicular direction of this projection optical system according to a projection optical system at an exposure substrate, scanning it, and exposing it.

[0029]After carrying out projection exposure of the manufacturing method of the device of this invention on an exposure substrate using composition (2-1) or the projection aligner of (2-2) according to the pattern projection optical system on an object face (3-1), it

is characterized by carrying out the development of this exposure substrate, and manufacturing a device.
[0030]
[Mode for carrying out the invention]It is an important section schematic view of Embodiment 1 of a projection aligner with which drawing 1 used some important section schematic views of Embodiment 1 of a lighting system of this invention, and drawing 2 used a lighting system of this invention.
[0031]The projection aligner of this embodiment can apply a step and repeat system and a step and scanning method.
[0032]Among a figure, 20 are a light source and comprise excimer laser, ultra-high pressure small ****, etc. which emit ultraviolet rays, a far ultraviolet ray, etc. After making into desired light flux form light flux which emitted the light source 20 through the light flux shaping means 21, change it into low light flux of coherence through the incoherent-ized means 22, and further by the emitting angle preservation optical element 23. It has entered into the condensing optical system 10, after eliminating influence by vibration between the light source 20 and a projection aligner, etc.
[0033]The light flux from the emitting angle preservation optical element 23 enters into the entrance plane 3a of the optical pipe (light flux mixing means) 3, after making a condensing point from the condensing optical system 10. the drive mechanism which is not illustrated near the emitting end (emission face) 3b of the optical pipe 3 -- attachment and detachment -- the exchangeable light flux adjustment device 11 (11a, 11b) is formed, and desired regulation is added to the luminous flux distribution which emits the optical pipe 3.
[0034]As shown in drawing 3 (A) and (B), the light flux adjustment device 11 (11a, 11b) to the entrance plane side Concave, It became the emission face side from the prism component (optical member) which has a conic surface of a convex, the vertical angles differ in the light flux adjustment devices 11a and 11b, and the direction of the light flux adjustment device 11a serves as form of the convex with it compared with the light flux adjustment device 11b. [a small namely, angle and] [sharper] The direction of the light flux adjustment device 11a forms in the entrance plane 5a of the multi luminous flux generator 5 by which the direction of the zona orbicularis with a big outer diameter and the light flux adjustment device 11b mentions the effective light source of the zona orbicularis with a small outer diameter later. 4 is a condenser and is condensing the high speed from the light flux adjustment device 11 to the entrance plane 5a of the multi luminous flux generator 5 which comprises the eye lens of a fly.
[0035]The condenser 4 carries out image formation of the emission face 3b of the light flux mixing means 3 to the entrance plane 5a of the multi luminous flux generator 5 for predetermined magnification, and both sides are made to become abbreviated conjugation relation mutually.
[0036]The neighborhood of emission face 5b of the eye 5 of a fly serves as a secondary light source, unnecessary light is shaded there and the effective light source of desired shape is orthopedically operated by form. 12 is a diaphragm -- near emission face 5b of the multi luminous flux generator 5 -- drive mechanism -- attachment and detachment -- it is provided exchangeable. The diaphragm 12 has two or more diaphragms (12a, 12b).
[0037]The diaphragms 12a and 12b have an opening shown in drawing 4 (A) and (B). In drawing 4, a shadow area is a shade part.
[0038]6 is an irradiation means, condenses the light flux which passed the opening of the diaphragm 12 among the light flux from the emission face 5b of the eye 5 of a fly, and is carrying out Koehler illumination of the irradiated plane (reticle) 7.
[0039]24 is a projection optical system and has projected a pattern drawn on the reticle (mask) 7 on the exposure substrate (wafer) 25.
[0040]In a projection aligner of this embodiment, it is changed into deformation illuminations, such as zona-orbicularis Lighting Sub-Division and quadrupole Lighting Sub-Division, by exchanging the light flux adjustment devices 11a and 11b etc. for insertion or other light flux adjustment devices.
[0041]He shades unnecessary light and is trying to form a desired effective light source configuration more correctly by inserting the diaphragm 12 near the emission face 5b of the multi luminous flux generator 5 if needed in that case.
[0042]Next, the features other than composition mentioned above among composition of this embodiment are explained.
[0043]Illuminance distribution formed by the entrance plane 5a of the eye 5 of a fly by the light flux adjustment device 11 changes with optical arrangement of the entrance plane 5a of form of the light flux adjustment device 11, the light flux adjustment device 11, the condenser 4, and the eye 5 of a fly, aberration of the condenser 5, etc.
[0044]When the light flux adjustment device 11a shown in drawing 3 (A) is used as the light flux adjustment device 11, as shown, for example in drawing 5, zona-orbicularis-like illuminance distribution may be formed on the entrance plane 5a of the eye 5 of a fly, and, in those intensity, dark space and a bright section may have an abrupt change dramatically.
[0045]The shadow area in drawing 5 is a portion with which light is irradiated, and the light intensity in the XX' section is shown below. Since the unnecessary light to desired effective light source distribution hardly arises in this case as shown in drawing 5, the above-mentioned diaphragm 12a becomes unnecessary.
[0046]On the other hand, as shown in drawing 6 depending on an illumination system, a sagging ** case has the upper part and the lower part like Gaussian distribution in the section of the light intensity of the zona orbicularis. In that case, unnecessary light is shaded by using the diaphragm 12a shown in drawing 4 (A).
[0047]A slash part of drawing 7 shows a portion which contributes to formation of effective light source distribution without being shaded when it extracts and 12a is used.
[0048]Drawing 8 is an explanatory view at the time of exchanging the light flux adjustment device 11a for the light flux adjustment device 11b in drawing 1.
[0049]As shown in drawing 9 the same with having mentioned above also in this case, zona-orbicularis-like a bright section and dark space of illuminance distribution of the eye 5 of the entrance plane 5a may carry out an abrupt change dramatically. [of a fly] In this case, it extracts and 12b is unnecessary. On the other hand, when intensity distribution in the entrance plane 5a of the eye 5 of a fly shows drawing 10, unnecessary light is too shaded using the diaphragm 12b. A slash part of drawing 11 shows a portion which it is not shaded when it extracts and 12b is used, but contributes to formation of effective light source distribution.
[0050]The above can respond also to deformation illuminations, such as a quadrupole, by changing the light flux adjustment device 11 similarly, although the case where zona-orbicularis Lighting Sub-Division was formed was described.
[0051]The light flux adjustment device 11c shown in drawing 3 (C) is an outer diameter of the light flux adjustment device for forming quadrupole Lighting Sub-Division, and comprises the prism component which has 4 pyramidal-surface form of a convex in the

entrance plane side at the emission face concave side.

[0052]Light flux enters only into the shadow area which this shows to drawing 12 at the entrance plane 5a of the eye 5 of a fly. Under the present circumstances, a diaphragm is also changed into the diaphragm 12c shown in drawing 4 (C), an effective light source is formed only in the portion which showed drawing 13 the slash, and the desired effective light source is formed. The figure and drawing 13 under drawing 12 show the intensity distribution in the AA' section of the figure on drawing 12.

[0053]In this case, as already stated in explanation of zona-orbicularis Lighting Sub-Division, the illuminance distribution by the side of the entrance plane 5a of the eye 5 of a fly is a case where it has an abrupt change by a bright section and dark space, but since it is the same as having mentioned above about a case [like Gaussian distribution] whose it is, explanation is omitted.

[0054]About the position from the optic axis of the discrete intensity distribution of a quadrupole, like the prism component of zona-orbicularis Lighting Sub-Division, it is adjusting the vertical angle of a four-sided pyramid, and can adjust to arbitrary positions.

[0055]The light flux adjustment device 11d shown in drawing 3 (D) is an explanatory view of the outer diameter of the light flux adjustment device for forming the effective light source which has intensity distribution, though intensity distribution is discretely as weak as a quadrupole into not a strong effective light source but other portions of a quadrupole.

[0056]The light flux adjustment device of drawing 3 (D) makes common the concave of the prism component of the light flux adjustment device 11c of drawing 3 (C), and the peak of a convex. The intensity distribution of the light flux which enters into the eye 5 of a fly by this becomes as [showed / in drawing 14].

[0057]At this embodiment, as explained above, it is not necessary to adjust other optical members in particular, and deformation illumination with high efficiency is made possible in the lighting system using the light flux mixing means 3 and the multi luminous flux generator 5 only by inserting the light flux adjustment device 11 corresponding to desired effective light source distribution immediately after the light flux mixing means 3.

[0058]By insertion of a light flux regulation means, although the light path length between a light flux mixing means and a condenser changes, Therefore, when inconvenience arises in an illumination system, also at the time of usual Lighting Sub-Division which does not use a light flux regulation means, abbreviation etc. are considered as a light flux regulation means, it is, and light path length's parallel plate is inserted, and at the time of deformation illumination, it may constitute so that it and a light flux regulation means may be exchanged.

[0059]Drawing 15 is some important section schematic views of Embodiment 2 of the lighting system of this invention.

[0060]This embodiment differs in the point which provided and constituted the diffraction optical elements 111 and 112 in the surface and rear surface of the plane-parallel plate 111a instead of the prism component of prescribed shape as the light flux adjustment device 11 (11e, 11f) compared with Embodiment 1 of drawing 1, and other composition is the same.

[0061]The same code number is given to the same element as the element shown by drawing 1 among the figure.

[0062]this embodiment -- Embodiment 1 -- the same -- near emitting end 3b of the light flux mixing means optical pipe 3 -- attachment and detachment -- the light flux adjustment devices 11e and 11f are formed exchangeable -- moreover -- the same -- near emission face 5b of the eye 5 of a fly -- attachment and detachment -- the exchangeable diaphragms 12e and 12f are established.

[0063]The light flux adjustment devices 11e and 11f provide and constitute the diffraction optical elements 111 and 112 respectively in the surface and rear surface of the plane-parallel plate 111a, as shown in drawing 16.

[0064]Drawing 16 shows the schematic view and some enlarged drawings in the section having contained optic-axis La of the light flux adjustment device 11e. The blazed form of the light flux adjustment device 11e is as having been shown in the enlarged drawing in a figure. That is, the diffraction optical element 111 has the operation which makes an optic axis and a counter direction diffract light, when light enters vertically. On the other hand, the diffraction optical element 112 has the operation which makes light diffract to the optic-axis La side, when light enters vertically.

[0065]Supposing the light flux adjustment device 11e is a light flux adjustment device which forms for example, zona-orbicularis Lighting Sub-Division, the phase distribution of the diffraction optical elements 111 and 112 will serve as a diffraction optical element which comprises a pattern of the concentric circle shape centering on an optic axis as shown in drawing 17.

[0066]Supposing the light flux adjustment device 11e is a light flux adjustment device which forms quadrupole Lighting Sub-Division, the phase distribution of the diffraction optical elements 111 and 112 will serve as a diffraction optical element arranged so that it may intersect perpendicularly with the pattern which adjoins a linear shape pattern, as shown in drawing 18.

[0067]Supposing the light flux adjustment device 11e is a light flux adjustment device which forms the effective light source distribution shown in drawing 14, The diffraction optical elements 111 and 112 turn into a diffraction optical element of the form kept from having a diffraction operation from what comprised a linear shape diffracted-light study lattice of drawing 18 in the center section containing optic-axis La, as shown in drawing 19.

[0068]At this embodiment, various deformation illuminations are efficiently formed by adjusting distribution of the light flux which enters into the eye 5 of a fly by these diffraction optical elements. As Embodiment 1 described, when the intensity distribution on the entrance plane 5a of the eye 5 of a fly has a slope like Gaussian distribution, extract near the eye 5 emission-face 5b of a fly, provide 12, it is made to change to compensate for change of the light flux adjustment device 11, and the effective light source distribution of desired form is formed.

[0069]As explained above, only by inserting the light flux adjustment device 11 corresponding to desired effective light source distribution immediately after the light flux mixing means 3 in the lighting system using the light flux mixing means 3 and the multi luminous flux generator 5 also in Embodiment 2, It is not necessary to adjust other optical members in particular, and deformation illumination with high efficiency is made possible.

[0070]Furthermore, since the light flux adjustment device 11 of Embodiment 1 comprised a prism component, in the case of the effective light source distribution for which it asked, it had processed the prism component based on it. On the other hand, since the light flux adjustment device is constituted using a diffraction optical element in this embodiment, if it is a range which micro processing for having a function as a diffraction optical element allows, any light flux adjustment devices can be created easily.

[0071]as shown in drawing 16 at that time, it is desirable from points, such as efficiency and a manufacture error, to form as a binary optical element which uses optical lithography technology, and considering efficiency, it is desirable to consider it as the binary optical element of eight or more levels.

[0072]Drawing 20 is some important section schematic views of Embodiment 3 of the lighting system of this invention.
[0073]It differs in that this embodiment carries out the placed opposite of the two components 111b and 112 which formed the diffraction optical element 111 (112) in the whole surface of the plane-parallel plate 111a (111b) as the light flux adjustment device 11, and constitutes them compared with Embodiment 2 of drawing 15, and other composition is the same.
[0074]The same code number is given to the same element as the element shown by drawing 15 among the figure.
[0075]this embodiment -- Embodiment 2 -- the same -- near emitting end 3b of the light flux mixing means (optical pipe) 3 -- attachment and detachment -- the light flux adjustment devices 11g and 11h are formed exchangeable -- moreover -- the same -- near emission face 5b of the eye 5 of a fly -- attachment and detachment -- the exchangeable diaphragms 12g and 12h are established.
[0076]Respectively, as shown in drawing 21, the light flux adjustment devices 11g and 11h carry out the placed opposite of the components 111b and 112b which formed the diffraction optical elements 111 and 112 to the whole surface of the plane-parallel plates 111a and 112a, and constitute them on it. Drawing 21 shows the schematic view and some enlarged drawings in the section having contained optic-axis La of the light flux adjustment device 11g.
[0077]The light flux adjustment device 11g has the two diffraction optical elements 111 and 112. The composition became an entrance plane of the plane-parallel plate 11a, and an emission face of the plane-parallel plate 112a from a blazed ****** diffraction grating element.
[0078]Since other operations and composition are the same as that of Embodiment 2, explanation is omitted.
[0079]As explained above, only by inserting the light flux adjustment device 11 corresponding to desired effective light source distribution immediately after the light flux mixing means 3 in a lighting system using the light flux mixing means 3 and the multi luminous flux generator 5 also in Embodiment 3, It is not necessary to adjust other optical members in particular, and deformation illumination with high efficiency is made possible.
[0080]Since a light flux adjustment device is constituted using a diffraction optical element like Embodiment 2, If it is a range which micro processing for having a function as a diffraction optical element allows, in that case, any light flux adjustment devices can be created easily, it is desirable from points, such as efficiency and a manufacture error, to form a diffraction optical element as a binary optical element which uses optical lithography technology, and considering efficiency, it is desirable to consider it as a binary optical element of eight or more levels.
[0081]Furthermore, it separates into the two plane-parallel plates 111a of the diffraction optical elements 111 and 112, and a 112a component, and constitutes from this embodiment, and the part and glass thickness are reduced.
[0082]Drawing 22 is an important section schematic view of Embodiment 4 of the lighting system of this invention, and is a schematic view of the lighting system used for the projection aligner of a step & repeat die or a step & scan type which manufactures devices, such as semiconductor chips, such as LSI and VLSI, CCD, a magnetic sensor, a liquid crystal element. It explains focusing on different composition from each embodiment mentioned above in Embodiment 4 below.
[0083]201 in drawing 22 Laser light sources, such as an ArF excimer laser (wavelength of about 193 nm), and a KrF excimer laser (wavelength of about 248 nm), The emitting angle (it saves) degree preservation optical element from which the emitting angle of the light flux which 202 emits even if incident light is displaced does not change, As for 203, objects, such as a condensing optical system and a mask (reticle) for which a multi luminous flux generator forms a zoom optical system and 207, the condensing optical system was formed 208, and, as for 204, the device pattern was formed 209 a light flux mixing means and 205, to be illuminated are shown. AX shows the optic axis of a lighting system.
[0084]11 can apply the same composition as each embodiment which is a light flux adjustment device and was mentioned above. 12 can apply the same composition as each embodiment which is a diaphragm and was mentioned above.
[0085]The condensing optical system 208 and the zoom optical system 205 comprise two or more lens elements fundamentally, and have at least one mirror for bending an optical path depending on the case. The number of lens elements may be one. The lens element of the plurality of two or more lens elements of especially a zoom optical system is constituted so that it may move in accordance with the optic axis AX with unillustrated drive mechanism, and it has changed image formation magnification by moving two or more lens elements to an optical axis direction by a predetermined relation, fixing the position of an image formation face.
[0086]The light flux mixing means 204 is the optical pipeline bunch which bundled a single optical pipeline or two or more optical pipelines, for example. The glass rod with which an optical pipeline comprises the polygonal pyramid which cut the multiple pillar [using ** material with sufficient transmissivity (quartz and fluorite)], or vertex side to the laser beam from the laser light source 201, The optical element of hollow like the kaleidoscope (kaleidoscope) which made each reflector meet and constituted the plane mirror of three or more sheets in tubed is comprised. Also in the optical element of this hollow, an outside serves as a polygonal pyramid which cut the multiple pillar or vertex side. It has reflectance flat [the reflector (it is the interface with air and the inside reflector in the case of a hollow optical element in the case of a glass rod) in the side of an optical pipeline], and high. The light flux mixing means 204 forms the surface light source (light) with uniform intensity distribution in the light emitting surface 204' or its neighborhood by making it spread, reflecting at least a part of incident light according to the reflector of the side, and mixing two or more beams of light of incident light. What has the same function as the light flux mixing means 204 and this hereafter is also called "internal reflection type integrator."
[0087]The multi luminous flux generator 207 consists of an eye lens, an optical fiber bundle, etc. of a fly which comprise two or more microlenses, and forms the surface light source (light) which divides into two or more portions the wave front of the incident light which entered into the light incidence face 207', and changes from two or more point light sources to the 207" of irradiation labor attendant or its neighborhood. The lights from two or more point light sources overlap mutually via a latter optical system, and form the surface light source (light) with uniform intensity distribution in a predetermined flat surface. What has the same function as the multi luminous flux generator 207 and this hereafter is also called "wavefront-splitting type integrator."
[0088]The laser beam ejected from the laser light source 201 enters into the outgoing radiation outlet angle degree preservation optical element 202 through the light flux leading-about optical system which comprises unillustrated a mirror and a relay lens. Even if the emitting angle degree preservation optical element 202 comprises the aperture 221 and the lens system 222 as shown in drawing 23 (A), an incoming beam is displaced within limits which tend to intersect perpendicularly with the optic axis AX and it changes from the light flux 227 to the state of the light flux 228, The degree phi of emitting angle of the light flux ejected from the emitting angle

degree preservation optical element 202 (difference angle) has fixed character.
[0089]The eye lens of the fly which comprises two or more microlenses 223 as shown in drawing 23 (B) may constitute the emitting angle degree preservation optical element 202. In this case, it depends for the degree phi of emitting angle on the form of a microlens. Even if an incoming beam is displaced within limits which tend to intersect perpendicularly with the optic axis AX and the optical element 202 of drawing 23 (B) also changes from the light flux 227 to the state of the light flux 228, its degree phi of emitting angle of the light flux emitted from the emitting angle degree preservation optical element 202 (difference angle) is constant. Wavefront-splitting type integrators other than the eye lens of a fly can apply as the emitting angle degree preservation optical element 202.
[0090]It is once condensed before an internal reflection type integrator by the condensing optical system 203, and the light flux (it is the multi luminous flux in the case of the eye lens of a fly) ejected from the emitting angle degree preservation optical element 202 with the degree phi of emitting angle enters by an emanating state in the internal reflection type integrator 204 after that. Carrying out a multiple echo in respect of the internal reflection, the sending light bunch which entered into the internal reflection type integrator 204 passes an inside, and forms two or more virtual images (apparent light source image) of the laser light source 201 in a flat surface vertical to the optic axis AX. Therefore, in irradiation labor attendant 204' of the internal reflection type integrator 204, since two or more light flux which is in sight as if it ejected from the virtual image of these plurality is piled up mutually, the illuminance distribution in irradiation labor attendant 204' becomes uniform. This phenomenon is explained later using drawing 25.
[0091]An angle of divergence (it is dependent on the emitting angle degree preservation optical element 202 and the condensing optical system 203) of a laser beam when entering into the internal reflection type integrator 204, If form of the internal reflection type integrator 204 is determined considering width (path) as the length of the internal reflection type integrator 204, It can set up more than coherence length with optical path length difference of each laser beam which comes out of each virtual image and enters into the object 209 to be illuminated peculiar to a laser beam, and generating of a speckle on the object 209 to be illuminated can be suppressed by carrying out by reducing temporal coherence of a laser beam. Now, the surface light source (light) with uniform illuminance distribution (light intensity distribution) which returned to drawing 22 and was formed in light emitting surface 204' of the internal reflection type integrator 204, For desired magnification, expansion image formation will be carried out by the zoom optical system 205 via the light flux adjustment device 11 on light incidence face 207' of the wavefront-splitting type integrator 207, and the uniform light source image 206 will be formed on light incidence face 207'.
[0092]If the uniform light source image 206 is formed on light incidence face 207', light intensity distribution of light incidence face 207' will be transferred by 207 " of irradiation labor attendants of the wavefront-splitting type integrator 207 as it is, The surface light source with uniform light intensity distribution which each intensity comprises from many mutual almost equal point light sources is formed in 207" of irradiation labor attendant, or its neighborhood.
[0093]Since each light flux ejected from many point light sources of 207" of irradiation labor attendant or its neighborhood illuminates an object according to the condensing optical system 208 via the diaphragm 12 so that it may overlap mutually on the object 209 to be illuminated, illuminance distribution of the illuminating object 209 whole becomes uniform.
[0094]The above-mentioned "desired magnification" is magnification to which a size of the uniform light source image 206 is set so that the difference angle (the degree of emitting angle) alpha of an irradiation light bunch which enters into the irradiated object 209 may become the optimal value for exposure, In the case of a mask (reticle) etc. in which an object to be illuminated has a minute pattern, this "desired magnification" is changed according to a kind (size of the minimum pattern line width) of mask pattern.
[0095]When setting "desired magnification" to m, the light incidence side numerical aperture of the zoom optical system 205 depending on the difference angle (the degree of emitting angle) beta of light flux emitted from the internal reflection type integrator 204 NA', NA'=m-NA" will be materialized if the optical outgoing radiation side numerical aperture of the zoom optical system 205 depending on the difference angle (the degree of incidence angle) theta of light flux which enters into the wavefront-splitting type integrator 207 is made into NA". Here, as for a size of the angle theta, it is desirable from a viewpoint of utilization efficiency of illumination light that it is a range which does not exceed the light incidence side numerical aperture NA of the wavefront-splitting type integrator 207, and is the value possible nearest to this numerical aperture NA.
[0096]Therefore, in the lighting system of this example, the value of the angle theta is not based on the value change of the magnification m, but is always made to be set as the optimal angle which suited the incidence side numerical aperture of the wavefront-splitting type integrator 207.
[0097]That is, the conditions of exposure of the kind of mask, etc. change, and when changing to such an extent that the value of the optimal magnification m of the zoom optical system 205 cannot be disregarded, the utilization efficiency of the illumination light is kept from falling by changing the value of the difference angle beta of the light flux emitted from the internal reflection type integrator 204. If the optimal magnification m for exposure of some conditions is decided, based on (1) type, the optimal angle of the difference angle beta of the light flux emitted from the internal reflection type integrator 204 (the degree beta of angle of emergence) will determine suitably.
[0098]It uses that the degree phi of incidence angle depends for the lighting system of this example on the difference angle (the degree of emitting angle) epsilon of the light flux from the emitting angle degree preservation optical element 202 equally to the degree phi of incidence angle of the light flux by which the value of the angle beta enters into the internal reflection type integrator 204, By switching the emitting angle degree preservation optical element 202 to the emitting angle degree preservation optical element from which other degrees epsilon of emitting angle differ according to an exposing condition, the value of the angle theta is maintained uniformly or almost uniformly.
[0099]The change of this emitting angle degree preservation optical element 202 is explained using drawing 24 (A) and (B).
[0100]In drawing 24, the degree epsilon of emitting angle of 202a (=epsilona) is a small emitting angle degree preservation optical element, the degree epsilon of emitting angle (=epsilonb) is a large emitting angle degree preservation optical element, and 202b points out the same component as the code number explained by drawing 22 about other code numbers.
[0101]In the lighting system of the projection aligner for semiconductor chip manufactures generally, Since it is required that the difference angle (the degree of incidence angle) alpha of the light flux which enters into the pattern formation face of the mask (reticle) which is the object 209 to be illuminated should be set as an optimal angle, and the utilization efficiency (light volume) of an incoming beam should also be maintained highly, In the lighting system of this example, a zoom optical system and two or more outgoing radiation degree preservation optical elements 202 were prepared, and it has attained by performing the change of zooming

and an optical element if needed [, such as change of the kind of mask,].
[0102]The degree alpha of incidence angle of light flux which enters into the mask 209 shows a case (this state is called state of "small sigma (sigma)".) where it is comparatively small, in size, minimum line width of a circuit pattern of the mask 209 comes comparatively, and drawing 24 (A) corresponds to a case (it is a submicron range). sigma (sigma) means a ratio (nickel/Np) of the several Np light incidence side opening of optical outgoing radiation side numerical aperture nickel of an illumination-light study system, and a projection optical system.
[0103]In order to set up a state of this small sigma, it is necessary to carry out image formation of light emitting surface 204' (surface light source in there or its neighborhood) of the internal reflection type integrator 204 for small magnification on light incidence face 207' of the wavefront-splitting type integrator 207. Although this is attained by making magnification of the zoom optical system 205 small, as mentioned above, the degree theta of incidence angle needs to be maintained by optimal angle depending on composition of the wavefront-splitting type integrator 204. Then, when changing into a state of this small sigma value, change magnification of a zoom optical system so that it may become the magnification corresponding to a value of the degree alpha of incidence angle, and. The degree of emitting angle switches the emitting angle degree preservation optical element 202b whose degree of emitting angle is epsilonb (>epsilona) to the emitting angle degree preservation optical element 202a which is epsilona so that a value of the degree theta of incidence angle may be maintained by optimum value.
[0104]The degree alpha of incidence angle of light flux which enters into the mask 209 shows a case (this state is called state of "large sigma (sigma)".) where it is comparatively large, and drawing 24 (B) corresponds, when minimum line width of a circuit pattern of the mask 209 is comparatively small (it is a submicron range). In order to set up a state of this large sigma, it is necessary to carry out image formation of light emitting surface 204' (surface light source in there or its neighborhood) of the internal reflection type integrator 204 to light incidence face 207' of the wavefront-splitting type integrator 207 for large magnification. Although this is attained by size attributing magnification of the zoom optical system 205 greatly, as mentioned above, the degree theta of incidence angle needs to be maintained by optimal angle depending on composition of the wavefront-splitting type integrator 4. Then, when changing into a state of this large sigma value, change magnification of a zoom optical system so that it may become the magnification corresponding to a value of the degree alpha of incidence angle, and. The degree of emitting angle switches the emitting angle degree preservation optical element 202a whose degree of emitting angle is epsilona (<epsilonb) to the emitting angle degree preservation optical element 202b which is epsilonb so that a value of the degree theta of incidence angle may be maintained by optimum value.
[0105]Here, although explanation which switches the image formation magnification of a zoom optical system and an emitting angle degree preservation optical element in two steps was performed, it can also constitute so that the image formation magnification of a zoom optical system and an emitting angle degree preservation optical element may be switched above a three-stage. Since the zoom optical system of the above-mentioned embodiment can change magnification continuously in the predetermined range, the magnification change more than a three-stage is easy, therefore can be used as it is, and the emitting angle degree preservation optical element should just prepare three or more kinds of emitting angle degree preservation optical elements from which a focal distance differs mutually. Even if it switches an emitting angle degree preservation optical element, the condensing position (absolute position of the real image of a light-emitting part or a virtual image which is in infinite distance in the case of this example) of the laser beam by them is considered as the composition maintained by approximately regulated.
[0106]Two or more sorts of image formation optical systems from which image formation magnification differs mutually as a zoom optical system are prepared, and it may be made to establish one image formation optical system selectively between the two integrators 204 and 207. On the other hand, the zoom optical system which has two or more lenses which move to an optical axis direction may be used for an emitting angle degree preservation optical element.
[0107]Next, why the illuminance distribution of irradiation labor attendant 204' of the internal reflection type integrator 204 becomes uniform is explained using drawing 25.
[0108]In drawing 25, the internal reflection type integrator 204 presupposes that it is a hexagonal prism-like glass rod. Drawing 25 is a sectional side elevation including the optic axis AX.
[0109]The laser beam from the unillustrated condensing optical system 203 once condenses to the focus P0 (image formation), and serves as a sending light bunch which has the angle of divergence phi after that. Since it is generally large intensity when a laser beam is an excimer laser beam at this time, it becomes an immense energy density and there is a possibility of destroying coating (antireflection film) of the light incidence face of the internal reflection type integrator 204 and the ** material itself about focal P0. Therefore, in such a case, its distance is kept a little from the focus P0 as a graphic display, and it arranges the internal reflection type integrator 204.
[0110]After the sending light bunch which entered into the internal reflection type integrator 204 passes an inside, reflecting repeatedly in respect of internal reflection (what is called total internal reflection), it is emitted from the internal reflection type integrator 204, with the degree 204I of angle of divergence at the time of entering maintained. Since the light flux reflected in each portion of the internal reflection side of the internal reflection type integrator 204 is emitting after a reflection at this time, the light flux reflected in each portion, The virtual image P1, P2, P3, P4, P5, P6, P7, P8, P9, and P10 are back formed as shown by the dashed line. Although not illustrated, in the case of the glass rod of a hexagonal prism, the same virtual-image group as the above is actually formed further by the remaining operation of 2 sets of internal reflection side pairs.
[0111]Therefore, in irradiation labor attendant 204' of the internal reflection type integrator 204, the light flux of a large number which are visible as if it ejected from the virtual image of these large number overlaps mutually, and illuminance distribution becomes uniform.
[0112]Drawing 26 shows the figure which looked at the arrangement of the virtual-image (apparent light source image) group produced with the internal reflection type integrator 204 of drawing 25 from the irradiation labor attendant of one microlens which constitutes the wavefront-splitting type integrator 207, for example in arrangement of drawing 24 (A). In drawing 26, 251 shows the microlens of the wavefront-splitting type integrator 207, and P1 to P10 shows the virtual image of drawing 25. When the internal reflection type integrator 204 is an optical pipeline of a hexagonal prism, a virtual-image group is arranged in the shape of [of a bee] a nest, as drawing 26 shows, but when the internal reflection type integrator 204 is an optical pipeline of a square pole, a virtual-image group is arranged in the shape of [rectangular] a lattice. This virtual image is an image of the condensing point (point light

source) of the laser beam formed between the condensing optical system 203 and the internal reflection type integrator 204.
[0113]Since the emitting angle degree preservation optical elements 202a and 202b are the eye lenses (m>=2, n>=2) of the fly which comprises the microlens of a mxn individual as the lighting system of this example was shown in drawing 24 (A), the virtual image of each of virtual-image groups comprises two or more images divided into the mxn grade. Therefore, the virtual image with which these division two or more images were located in a line in the shape of [of the bee] a nest will be in sight, and these will correspond [even the microlens of the wavefront-splitting type integrator 207].
[0114]Therefore, the lighting system of this example, The number of the point light sources (effective light source) at the time of superimposing each light flux from two or more point light sources (effective light source) formed in 207" of light emitting surface of the wavefront-splitting type integrator 207 or its neighborhood on the object 209 to be illuminated according to the condensing optical system 208, and illuminating it is made very large, It makes it possible to illuminate the object 209 so that the illuminating object 209 whole may serve as more uniform illuminance distribution.
[0115]Since the degree epsilon of outgoing radiation of the light flux from the emitting angle degree preservation optical elements 202a and 202b is uniformly maintained even if the light flux from the laser light source 201 carries out minute displacement by disturbance as drawing 23 (B) explained, each of division two or more images in drawing 26 only carries out minute change — a swage block -- there being no change in the virtual-image group which constitutes **, and, It becomes small to such an extent that there is almost no change when the whole virtual image in each microlens 251 of the emitting angle degree preservation optical element 202a and the 202b wavefront-splitting type integrator 207 is seen macroscopically, therefore the influence of the illuminance distribution on [on the object 209 to be illuminated] can also be disregarded.
[0116]Therefore, the lighting system of this example is a system whose performance is dramatically stable, even if the laser beam from the laser light source 201 is displaced. The light flux adjustment device 11 and the optical effect of the diaphragm 12 are the same as that of each above-mentioned embodiment.
[0117]Embodiment 2 which applied the lighting system of the above-mentioned embodiment to the step & repeat die which manufactures devices, such as semiconductor chips, such as LSI and VLSI, CCD, a magnetic sensor, a liquid crystal element, or the step & scan type projection aligner is shown in drawing 27.
[0118]A light flux plastic surgery optical system for 291 to operate orthopedically in drawing 27 to the shape of beam of a request of the parallel pencil from the laser light source 201 of an ArF excimer laser, KrF excimer laser laser, etc., An incoherent-ized optical system for 292 to make coherent laser luminous flux incoherent, the projection optical system on which 293 projects the actual size image or reduced image of a circuit pattern of the mask 209, and 294 show the wafer which applied sensitization material to the substrate (silicon and glass). The same code number as drawing 22 is given to the same component as the component shown in drawing 22 here, and explanation is omitted.
[0119]As for the laser beam from the laser light source 201, when chromatic aberration correction of the projection optical system 293 is not carried out, half breadth of the spectral line is narrow-band-ized by about 1pm-3pm, When chromatic aberration correction of the projection optical system 293 is carried out, half breadth of the spectral line is narrow-band-ized by the existing value of 10 or more pm. When chromatic aberration correction of the projection optical system 293 is carried out, the laser beam which is not narrow-band-ized may be used.
[0120]As the projection optical system 293, the optical system constituted from the optical system, two or more lens elements, and diffraction optical elements, such as kino form of at least one sheet, which were constituted from the optical system, two or more lens elements, and the concave mirror of at least one sheet which were constituted only from two or more lens elements can be used. Amendment of a chromatic aberration uses two or more lens elements which comprise the ** material from which a variance (Abbe number) differs mutually, or it constitutes them so that distribution of a lens element and an opposite direction may produce the above-mentioned diffraction optical element.
[0121]The laser beam ejected from the laser light source 201 enters into the light flux plastic surgery optical system 291 through the light flux leading-about optical system which comprises unillustrated a mirror and a relay lens. This light flux plastic surgery optical system 291 comprises two or more cylindrical lenses, beam expanders, etc., and is changed into the value of a request of the horizontal-to-vertical ratio of the size of the sectional shape (it is vertical to the optic axis AX) of a laser beam.
[0122]Light flux by which sectional shape was orthopedically operated by the light flux plastic surgery optical system 291 enters into the incoherent-ized optical system 292 in order to prevent light's interfering on the wafer 294 and producing a speckle, and it is changed into incoherent light flux which a speckle does not produce easily due to the optical system 292.
[0123]. As [indicate /, for example / as the incoherent-ized optical system 292 / by drawing 1 of JP,H3-215930,A] After branching an incoming beam in respect of light dividing to at least two light flux (for example, p-polarized light and s-polarized light), one light flux via an optical member. After giving optical path length difference more than coherence length of a laser beam to light flux of another side, an optical system provided with at least one clinch system which carries out a re-light guide to this parting plane, piles up with light flux of another side, and was made to be ejected can be used.
[0124]Light flux made incoherent from the incoherent-ized optical system 292 enters into the emitting angle degree preservation optical element 202. By a procedure described using drawing 22 thru/or drawing 26 below, light flux emitted from each infinitesimal area (microlens) of the wavefront-splitting type integrator 207 superimposes the mask 209 according to the condensing optical system 208, and illuminates, Uniform illumination of the mask 209 is carried out so that uniform illuminance distribution may be acquired all over the circuit pattern which should project the mask 209. And projection imaging of the circuit pattern formed on the mask 209 is carried out by the projection optical system 293 on the wafer 294, and exposure of a circuit pattern (image) to photosensitive materials of the wafer 204 is performed. The wafer 294 is being fixed to an unillustrated XYZ movable stage by a vacuum absorption method etc., a XYZ movable stage has a function which carries out parallel translation before and after four directions of space, and the movement is controlled by length measuring machines, such as an unillustrated laser interferometer. Since such technology is well-known technology, detailed explanation is omitted.
[0125]In drawing 27, the aperture diaphragm 12 for Lighting Sub-Division is arranged in the optical outgoing radiation side optical path of the wavefront-splitting type integrator 207, By the diaphragm 12 having provided two or more aperture diaphragms corresponding to a mutually different sigma value in the disk (turret) etc., interlocking it with zooming of a zoom optical system, and the change of an emitting angle degree preservation optical element, and rotating a disk, It constitutes so that a desired aperture diaphragm may be

inserted according to a sigma value into the optical outgoing radiation side optical path of the wavefront-splitting type integrator 207.
[0126]As aperture shape of two or more aperture diaphragms, four openings outside the optic axis indicated to a usual circular opening and annulus ring (ring)-like opening, or JP,H4-329623,A (Suzuki), etc. can be used.
[0127]Embodiment 5 of the lighting system of this invention is described using drawing 28 and drawing 29.
[0128]Drawing 28 and drawing 29 are the schematic views of a suitable lighting system for a step & scan (scan) type projection aligner which manufactures devices, such as semiconductor chips, such as LSI and VLSI, CCD, a magnetic sensor, a liquid crystal element. Only a different portion from each embodiment mentioned above in drawing 28 and drawing 29 is explained.
[0129]The case where drawing 28 (A) and (B) has a lighting system of this example in the state of above-mentioned small sigma is shown, (A) is the figure which looked at the lighting system from the scanning direction (it is hereafter described as "the direction of z".), and (B) is the figure which looked at the lighting system from the direction (it is hereafter described as a "y direction".) which intersects perpendicularly with a scanning direction. The case where drawing 29 (A) and (B) has a lighting system of this example in the state of above-mentioned large sigma is shown, (A) is the figure which looked at the lighting system from the direction of z, and (B) is the figure which looked at the lighting system from the y direction.
[0130]A section including the axis prolonged in the direction of z from xy section and the optic axis AX in the section which includes hereafter the optic axis AX and the axis prolonged in a y direction from the optic axis AC in drawing 29 (A) and (B) is described as xz section. The emitting angle degree preservation optical element with which the difference angle (the degree of emitting angle) of an outgoing beam differs between 220a and 220b in drawing 28 and drawing 29 in XY section and XZ section, An internal reflection type integrator and 240' 240 The light emitting surface of an internal reflection type integrator, As for 270, the light incidence face of a wavefront-splitting type integrator, a light emitting surface, and 300y show a wavefront-splitting type integrator, 270', and 270 " of z lay length of the Lighting Sub-Division region (light) on a mask, as for the length of the y direction of the Lighting Sub-Division region (light) on a mask, and 300z. The same code number as drawing 24 is given to the same component as the component shown by drawing 22 thru/or drawing 27 in a figure.
[0131]The fundamental composition and function of the lighting system of this example which are shown by drawing 28 and drawing 29, It is the same as the lighting system of said embodiment shown by drawing 22 thru/or drawing 27 also including the modification, and the point of difference with the lighting system of said embodiment of the lighting system of this example is in the composition and the function of an emitting angle degree preservation optical element, an internal reflection type integrator, and a wavefront-splitting type integrator. Therefore, only a point of difference with said embodiment will be explained here.
[0132]It is necessary to form effectively on the mask 209 the Lighting Sub-Division region of rectangle (y direction is longer than direction of z) slit shape which extended in the y direction in a step & scan type projection aligner.
[0133]Then, the section which includes the optic axis AX and the axis prolonged in a y direction from the optic axis AX as an emitting angle degree preservation optical element in this example. (it is hereafter described as "xy section".) — the axis prolonged in the direction of z is included from the focal distance, the optic axis AX, and the optic axis AX which are related — a section. (it is hereafter described as "xz section".) — the related focal distance as an internal reflection type integrator using the elements 220a and 220b which comprise a mutually different anamorphic optical system, The form of the section (it is hereafter described as "yz section".) which intersects perpendicularly with an optic axis uses the integrator 240 which comprises the optical pipeline of the square pole expressed with the straight line of the couple prolonged in a y direction, and the straight line of the couple prolonged in the direction of z, As a wavefront-splitting type integrator, the form of yz section of each microlens uses the integrator 270 which comprises the fly eye lens which is a rectangle prolonged in a y direction.
[0134]The emitting angle degree preservation optical elements 220a and 220b, The focal distance in xy section is respectively smaller than the focal distance in xz section, therefore emitting angle degree epsilonay in yz section and the epsilonby of the relation of the difference angle (the degree of emitting angle) of the light flux seen in each section are larger than emitting angle degree epsilonaz in xz section, and epsilonbz. Therefore, the relations of difference angle (degree of emitting angle or degree of incidence angle) phiy of the illustrated light flux, phiz, betay, betaz, thetay, thetaz, gammay, gammaz, alphay, and alphaz are also phiy>phiz, betay>betaz, thetay>thetaz, gammay>gammaz, and alphay>alphaz. Here, since it is gammay>gammaz, on the mask 9, the Lighting Sub-Division region of rectangle slit shape which extended in the y direction is formed.
[0135]Like said embodiment, depending on size of sigma, there is a relation of epsilon ay<epsilon by and epsilon az<epsilon bz, and there is a relation of phiy=betay and phi z=beta z depending on character of a prismatic optical pipeline.
[0136]The emitting angle degree preservation optical elements 220a and 220b can also apply an element using what has the slit opening prolonged in a y direction as the diaphragm 221 of a fly eye lens and drawing 23 (A) which put in order two or more microlenses from which a focal distance differs along yz section in xy section and xz section in two dimensions. A microlens which constitutes each fly eye lens is constituted by a usual lens and a diffraction optical element (Fresnel lens).
[0137]Drawing 30 shows a figure which looked at arrangement of a virtual-image (apparent light source image) group produced with drawing 28 and the internal reflection type integrator 240 of drawing 29 from an irradiation labor attendant of one microlens which constitutes the wavefront-splitting type integrator 270. In drawing 30, 320 shows a microlens of the wavefront-splitting type integrator 270, and Y1 to Y12 and Z1 to Z8 shows a virtual image.
[0138]It passes, when drawing 30 shows, and since the internal reflection type integrator 240 is an optical pipeline of a square pole, a virtual-image group meets with a y direction and the direction of z, and is arranged in the shape of a lattice. Since xy section differs in the degree of incidence angle of the sending light bunch which enters into the internal reflection type integrator 240 mutually from xz section, the reflecting times in an internal reflection side differ mutually in xy section and xz section, therefore the number of virtual images differs in the y direction and the direction of z. This virtual image is an image of the condensing point (point light source) of the laser beam formed between the condensing optical system 203 and the internal reflection type integrator 240.
[0139]Since the emitting angle degree preservation optical elements 220a and 220b are the eye lenses (m>=2, n>=2) of the fly which comprises the microlens of a mxn individual as the lighting system of this example was shown in drawing 28 and drawing 29, the virtual image of each of virtual-image groups comprises two or more images divided into the mxn grade. Therefore, the virtual image with which these division two or more images were located in a line in the shape of a lattice will be in sight, and, even in the microlens of the wavefront-splitting type integrator 270, these will correspond.
[0140]Therefore, the number of the point light sources (effective light source) at the time of the lighting system of this example also

superimposing each light flux from two or more point light sources (effective light source) formed in 207″ of light emitting surface of the wavefront-splitting type integrator 270 or its neighborhood on the mask 209 according to the condensing optical system 208, and illuminating it is made very large, It makes it possible to illuminate the mask 209 so that the mask 209 whole may serve as more uniform illuminance distribution.
[0141]The lighting system of this example which has the above composition as well as said embodiment, When making the state of small sigma, and the state of large sigma according to the kind of mask 209, etc., By switching the image formation magnification of the zoom optical system 205 between a small value and a big value, and switching the emitting angle degree preservation optical element 220a and the emitting angle degree preservation optical element 220b, It is possible regularity or to change sigma for each value of angle thetay and thetaz, without being able to change each value of angle alphay and alphaz and reducing the utilization efficiency of light, maintaining almost uniformly. Even if the laser beam from a laser light source is displaced, illumination unevenness does not arise on the mask 209.
[0142]Embodiment 3 which applied the lighting system shown in drawing 31 by drawing 28 thru/or drawing 30 to scanning type exposure devices, such as a step & scan type which manufactures devices, such as semiconductor chips, such as LSI and VLSI, CCD, a magnetic sensor, a liquid crystal element, is shown.
[0143]A light flux plastic surgery optical system for 291 to operate orthopedically in drawing 31 to the shape of beam of a request of the light flux from the laser light sources 201, such as an ArF excimer laser and a KrF excimer laser, An incoherent-ized optical system for 292 to make coherent laser luminous flux incoherent, the projection optical system on which 293 projects the actual size image or reduced image of a circuit pattern of the mask 209, and 294 show the wafer which applied sensitization material to the substrate (silicon and glass). The same code number as drawing 28 thru/or drawing 30 is given to the same component as the component shown in drawing 28 thru/or drawing 30 here, and explanation is omitted.
[0144]The laser beam ejected from the laser light source 201 enters into the light flux plastic surgery optical system 291 through the light flux leading-about optical system which comprises unillustrated a mirror and a relay lens. This light flux plastic surgery optical system 291 comprises two or more cylindrical lenses, beam expanders, etc., and is changed into the value of a request of the horizontal-to-vertical ratio of the size of the sectional shape (it is vertical to the optic axis AX) of a laser beam.
[0145]The light flux by which sectional shape was orthopedically operated by the light flux plastic surgery optical system 291 enters into the incoherent-ized optical system 292 in order to prevent light's interfering on the wafer 294 and producing a speckle, and it is changed into the incoherent light flux which a speckle does not produce easily due to the optical system 292.
[0146]As the incoherent-ized optical system 292, the above-mentioned optical system which is indicated by drawing 1 of JP,H3-215930,A can be used.
[0147]The light flux made incoherent from the incoherent-ized optical system 292 enters into the emitting angle degree preservation optical element 220a or 220b. By the procedure described using drawing 23 thru/or drawing 26 in the first embodiment below, and the same procedure. From each infinitesimal area (microlens) of the wavefront-splitting type integrator 270, the emitted light flux superimposes the mask 209 according to the condensing optical system 208, and illuminates, and uniform illumination of the mask 209 is carried out so that uniform illuminance distribution may be acquired all over the circuit pattern which should project the mask 209. At this time, the Lighting Sub-Division region (light) of rectangle slit shape extended to a y direction is formed on the mask 209. And projection imaging of the portion in which said Lighting Sub-Division region of the circuit patterns formed on the mask 209 was formed is carried out by the projection optical system 293 on the wafer 294, and exposure of the circuit pattern (image) to the photosensitive materials of the wafer 294 is performed.
[0148]The wafer 294 is being fixed to the XYZ movable stage movable for [of unillustrated xyx] all directions by the vacuum absorption method etc., The mask 209 is also being fixed to the XYZ movable stage movable for [of unillustrated xyx] all directions by the vacuum absorption method etc., and movement of each XYZ movable stage is controlled by length measuring machines, such as an unillustrated laser interferometer. And by moving each XYZ movable stage to the end of the circuit pattern part of the mask 209, where the Lighting Sub-Division region of rectangle slit shape is formed, scanning the mask 209 in the direction of z, and scanning the wafer 294 in the direction of -z, The whole circuit pattern of the mask 209 is projected on the wafer 294, and the whole circuit pattern is transferred on the wafer 294. The projecting magnification of the projection optical system 293 of the scan speed of the wafer 294 is -MxV when the scan speed of M and the mask 209 is V.
[0149]Drawing 32 is a flow chart of the manufacturing method of the devices (semiconductor chips, such as IC and LSI, or a liquid crystal panel, CCD, etc.) of this invention. This is explained.
[0150]The circuit design of a semiconductor device is performed at Step 1 (circuit design).
[0151]The mask in which the designed circuit pattern was formed is manufactured at Step 2 (mask manufacture). On the other hand, at Step 3 (wafer manufacture), a wafer is manufactured using materials, such as silicon.
[0152]Step 4 (wafer process) is called a previous process, and forms a actual circuit on a wafer with a lithography technology using the mask (reticle) and wafer (the 2nd object) which formed the prepared aforementioned circuit pattern (the 1st object) using the exposure device of this invention.
[0153]Step 5 (assembly) is called a post process, is a process semiconductor-chip-ized using the wafer produced by Step 4, and includes processes, such as an assembly process (dicing, bonding) and a packaging process (chip enclosure).
[0154]At Step 6 (inspection), the operation confirming test of the semiconductor device produced at Step 5, an endurance test, etc. are inspected. A semiconductor device is completed through such a process and this is shipped (Step 7).
[0155]Drawing 33 is a flow chart of the above-mentioned wafer process.
[0156]The surface of a wafer is oxidized at Step 11 (oxidation).
[0157]An insulator layer is formed in a wafer surface at Step 12 (CVD).
[0158]At Step 13 (electrode formation), an electrode is formed by vacuum evaporation on a wafer.
[0159]Ion is driven into a wafer at Step 14 (ion implantation).
[0160]A sensitizing agent is applied to a wafer at Step 15 (resist process).
[0161]At Step 16 (exposure), printing exposure of the circuit pattern of a reticle is carried out with the exposure device of this invention at a wafer.
[0162]The exposed wafer is developed at Step 17 (development).

[0163]Portions other than the developed resist are shaved off at Step 18 (etching).
[0164]The resist which etching ended and became unnecessary is removed at Step 19 (resist removing).
[0165]A circuit pattern is formed on a wafer by carrying out by repeating these steps multiplex.
[0166]If the manufacturing method of this embodiment is used, a semiconductor device can be manufactured conventionally in a short time.
[0167]
[Effect of the Invention]According to this invention, the change of illumination and a deformation illumination method is usually easy by setting up each element as mentioned above, And an irradiated plane can be uniformly illuminated by high illumination efficiency, and the manufacturing method of the lighting system which can manufacture easily the device which is the degree of high integration and the projection aligner using it, and a device can be attained.
[0168]Especially according to this invention, the change of Lighting Sub-Division and deformation illumination can usually be easily realized for taking the light flux adjustment device of various composition in and out immediately after a light flux mixing means, and the effect of being able to use illumination luminous flux at high efficiency is acquired.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The important section schematic view of Embodiment 1 of the lighting system of this invention
[Drawing 2]The important section schematic view of Embodiment 1 of the projection aligner using the lighting system of this invention

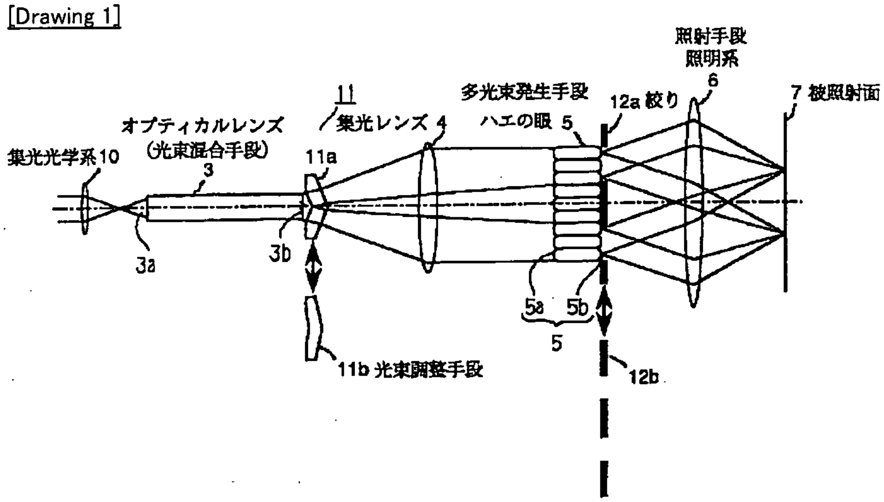
[Drawing 3]The schematic view of the light flux adjustment device concerning this invention
[Drawing 4]The schematic view of the diaphragm adjustment means concerning this invention
[Drawing 5]The schematic view of the illuminance distribution in the entrance plane of the eye of the fly concerning this invention
[Drawing 6]The schematic view of the illuminance distribution in the entrance plane of the eye of the fly concerning this invention
[Drawing 7]The explanatory view which expresses the effective light source at the time of shading unnecessary light with the diaphragm concerning this invention
[Drawing 8]The schematic view at the time of exchanging the light flux adjustment device concerning this invention
[Drawing 9]The schematic view of the illuminance distribution in the eye entrance plane of the fly concerning this invention
[Drawing 10]The schematic view of the illuminance distribution in the eye entrance plane of the fly concerning this invention
[Drawing 11]The explanatory view which expresses the effective light source at the time of shading unnecessary light with the diaphragm concerning this invention
[Drawing 12]The schematic view of the illuminance distribution in the eye entrance plane of the fly in quadrupole Lighting Sub-Division concerning this invention
[Drawing 13]The explanatory view which expresses the effective light source at the time of shading unnecessary light with the diaphragm concerning this invention
[Drawing 14]The explanatory view of the effective light source distribution concerning this invention
[Drawing 15]Some important section schematic views of Embodiment 2 of the lighting system of this invention
[Drawing 16]The schematic view of the light flux adjustment device concerning this invention
[Drawing 17]The explanatory view of the phase distribution of the diffraction optical element as a light flux adjustment device concerning this invention
[Drawing 18]The explanatory view of the phase distribution of the diffraction optical element as a light flux adjustment device concerning this invention
[Drawing 19]The explanatory view of the phase distribution of the diffraction optical element as a light flux adjustment device concerning this invention
[Drawing 20]Some important section schematic views of Embodiment 3 of the lighting system of this invention
[Drawing 21]The schematic view of the light flux adjustment device concerning this invention
[Drawing 22]The schematic view showing Embodiment 4 of the lighting system of this invention
[Drawing 23]The schematic view showing two examples of an emitting angle degree preservation optical element
[Drawing 24]The explanatory view about the change of an emitting angle degree preservation optical element
[Drawing 25]The explanatory view about the function of an internal reflection type integrator
[Drawing 26]The explanatory view showing the virtual-image group formed by drawing 22 thru/or the internal reflection type integrator 204 of drawing 25
[Drawing 27]An exposure device which carries the lighting system of drawing 22 in the schematic view showing Embodiment 2 of the exposure device of this invention
[Drawing 28]An equipment configuration figure [in / in the schematic view showing Embodiment 5 of the lighting system of this invention / the state of small sigma]
[Drawing 29]An equipment configuration figure [in / in the schematic view showing Embodiment 5 of the lighting system of this invention / the state of large sigma]
[Drawing 30]The explanatory view showing the virtual-image group formed by drawing 28 and the internal reflection type integrator 240 of drawing 29
[Drawing 31]The exposure device figure which carries the lighting system which drawing 28 and drawing 29 show in the schematic view showing Embodiment 3 of the exposure device of this invention
[Drawing 32]The flow chart of the manufacturing method of the device of this invention
[Drawing 33]The flow chart of the manufacturing method of the device of this invention
[Drawing 34]The important section schematic view of the conventional lighting system
[Drawing 35]Some explanatory views of drawing 24
[Drawing 36]Some explanatory views of drawing 24
[Drawing 37]Some explanatory views of drawing 24
[Explanations of letters or numerals]
1 Mercury-vapor lamp (light source)

2 Elliptical mirror
3 Light flux mixing means
4 Condenser
5 Multi luminous flux generator
6 Irradiation means
7 Irradiated plane (reticle)
10 Condensing optical system
11 Light flux adjustment device
12 Diaphragm
24 Projection lens
25 Sensitized substrate
201 Laser light source
202 Angle-of-emergence degree preservation optical element
203 Condensing optical system
204 Internal reflection type integrator
205 Zoom optical system
207 Wavefront-splitting type integrator
208 Condensing optical system
209 Mask
293 Projection optical system
294 Wafer

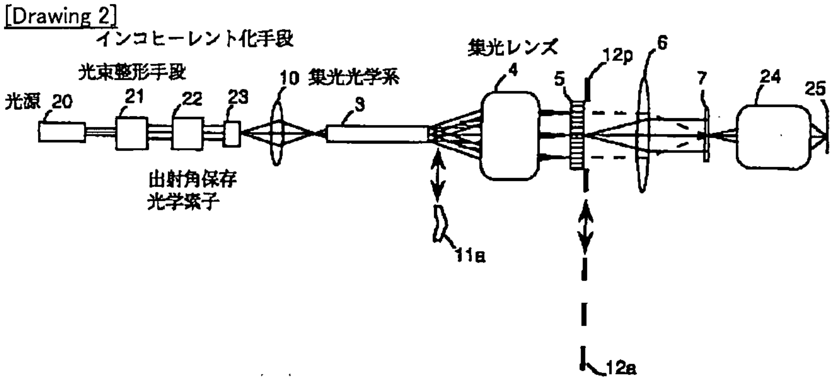
[Translation done.]

DRAWINGS

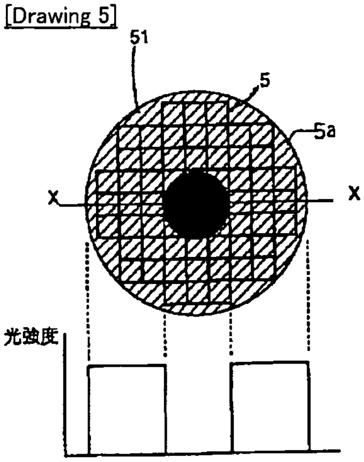
[Drawing 1]



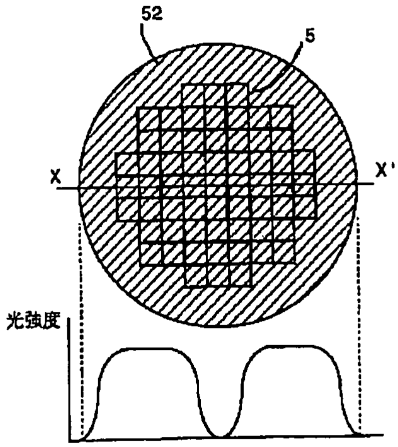
[Drawing 2]



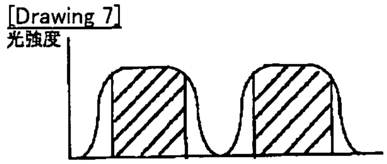
[Drawing 5]



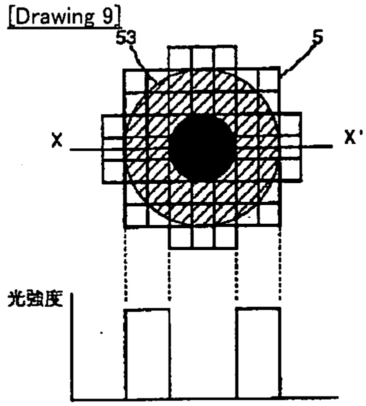
[Drawing 6]



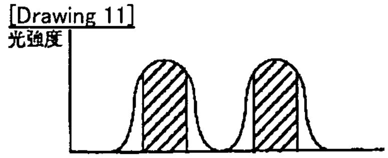
[Drawing 7]



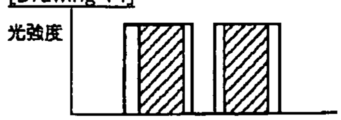
[Drawing 9]



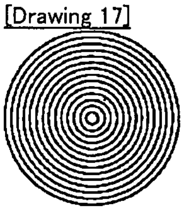
[Drawing 11]



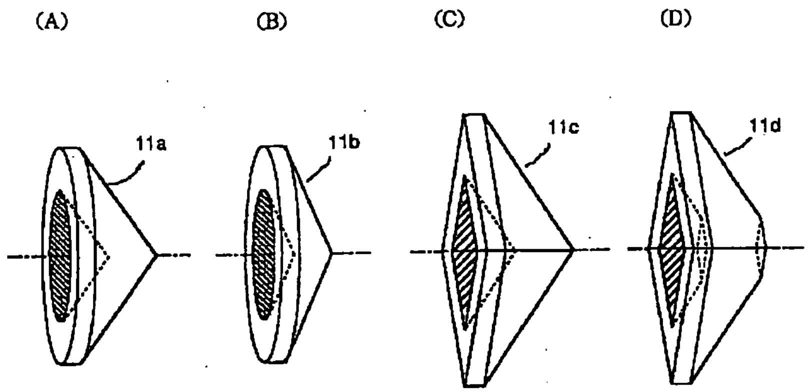
[Drawing 14]



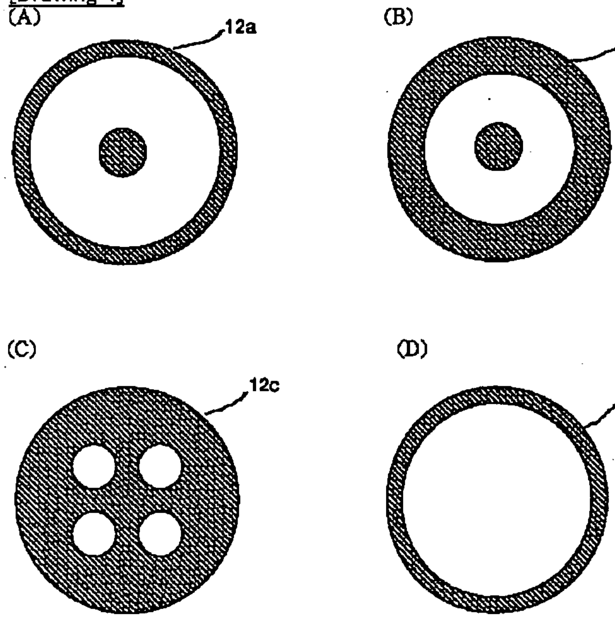
[Drawing 17]



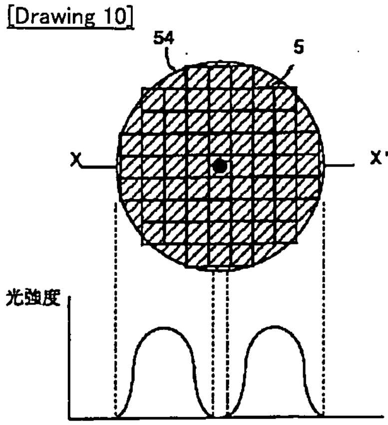
[Drawing 3]



[Drawing 4]



[Drawing 10]



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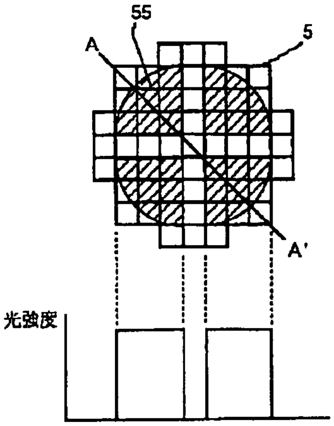
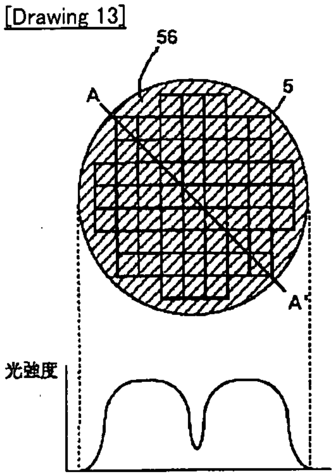
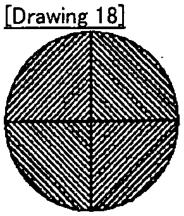


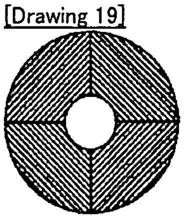
[Drawing 13]



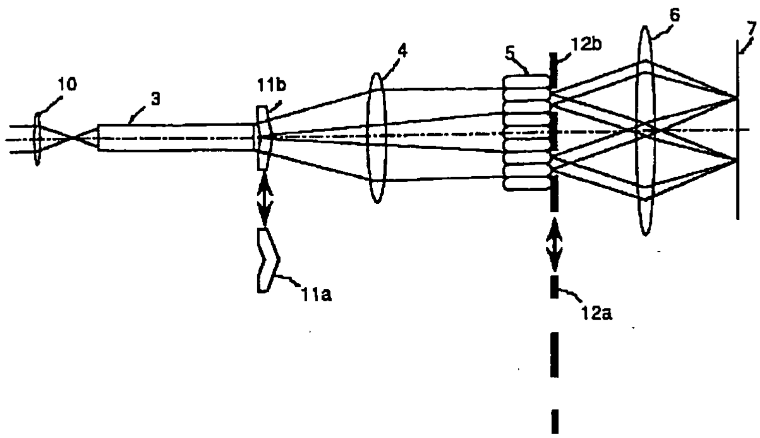
[Drawing 18]



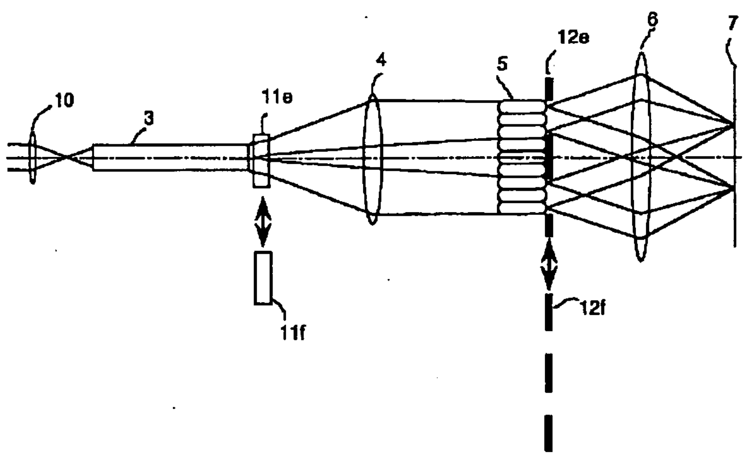
[Drawing 19]



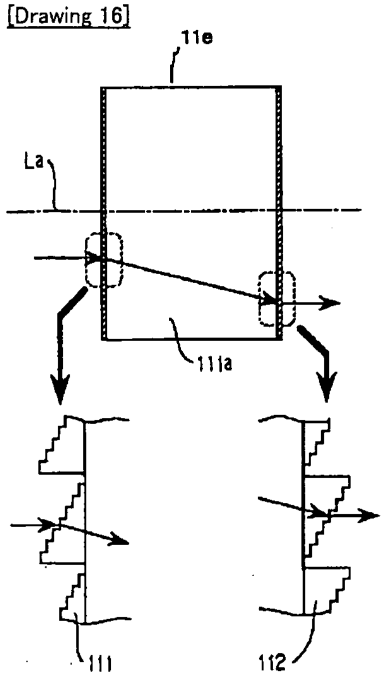
[Drawing 8]



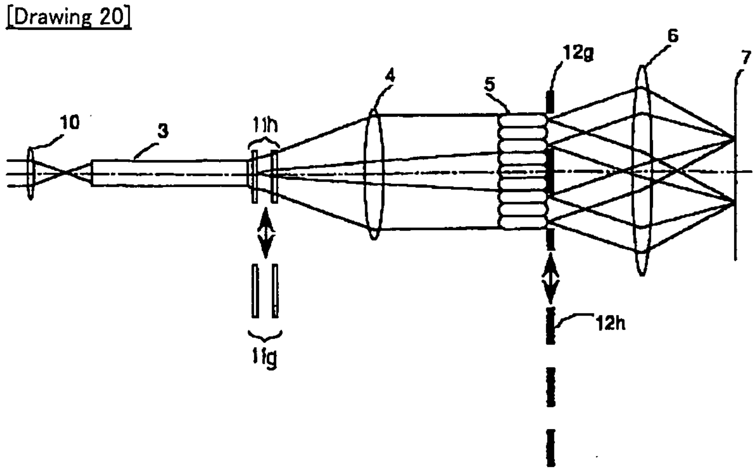
[Drawing 15]



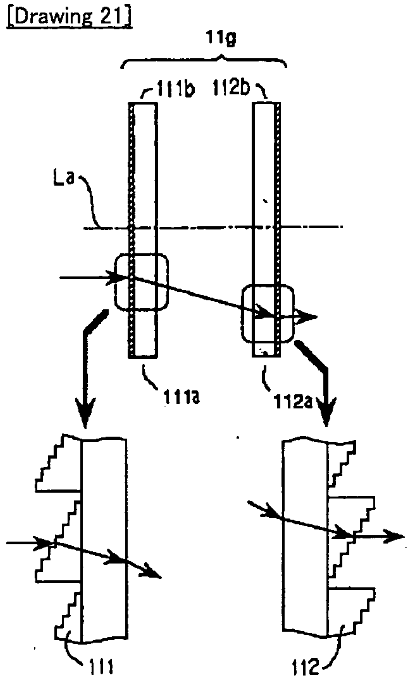
[Drawing 16]



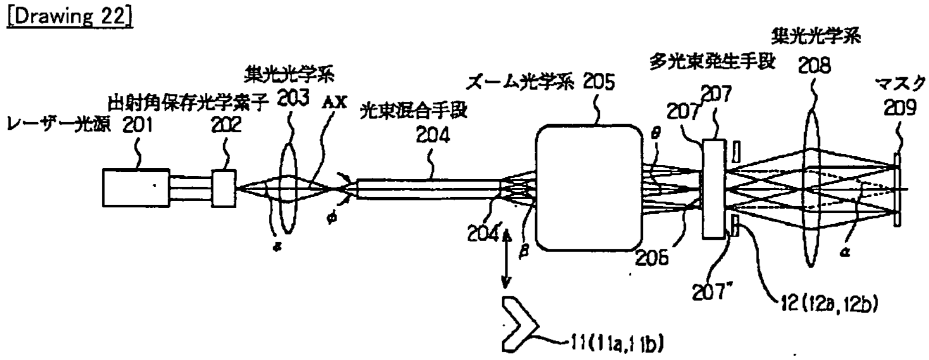
[Drawing 20]



[Drawing 21]

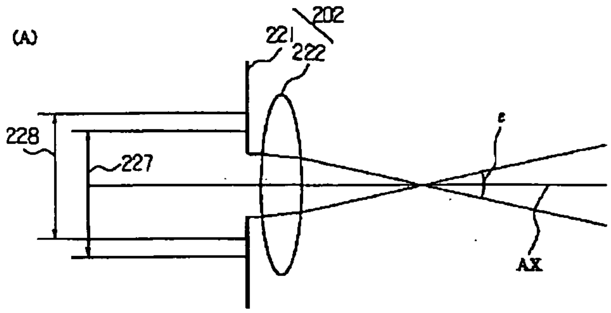


[Drawing 22]

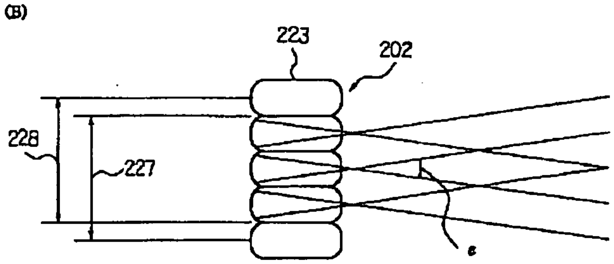


[Drawing 23]

(A)



(B)



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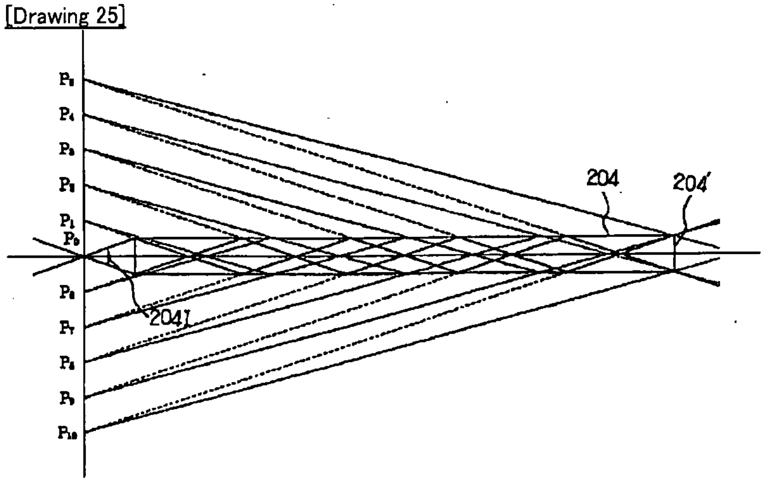
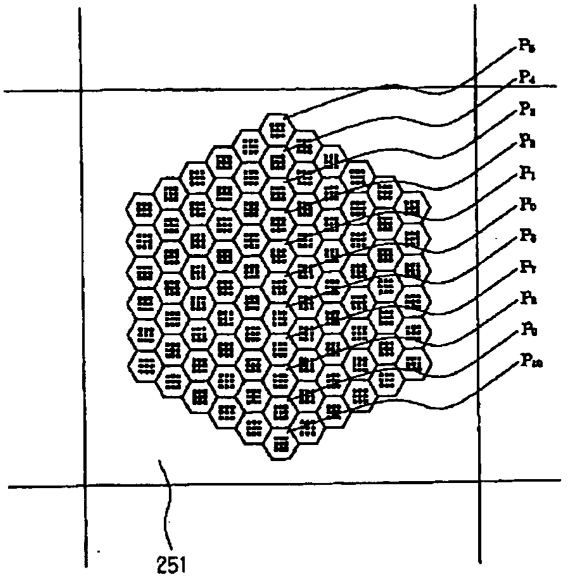
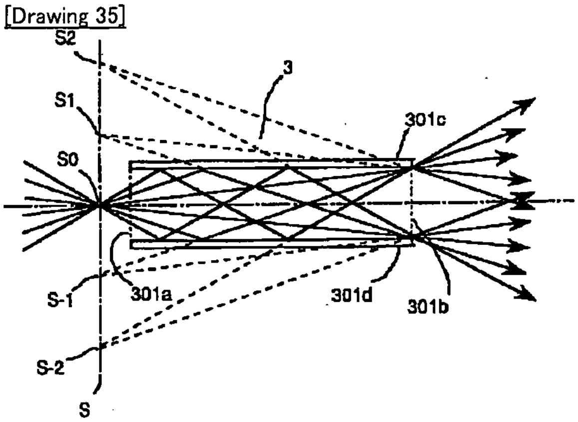


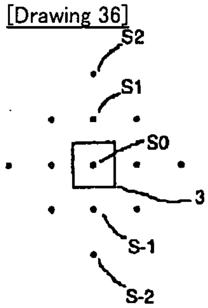
[Drawing 26]



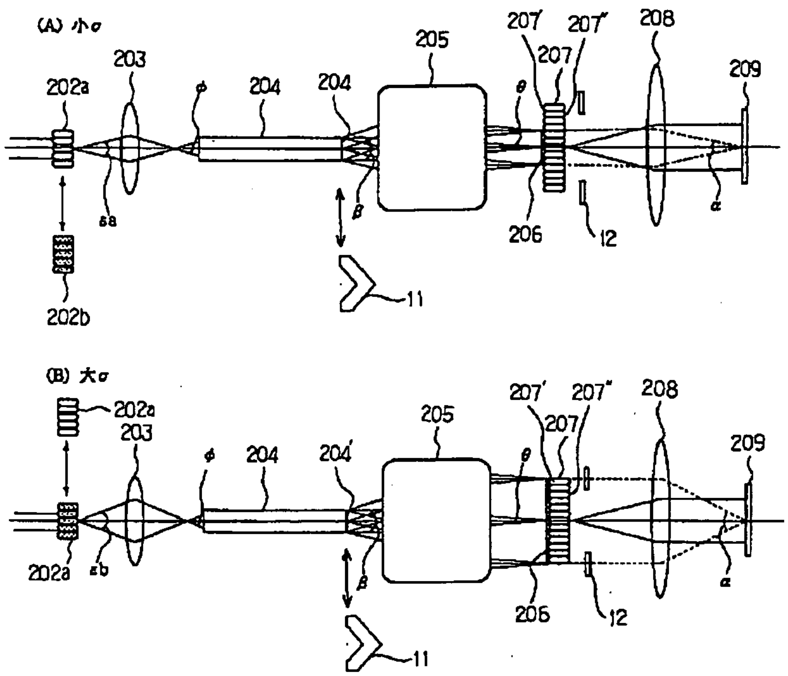
[Drawing 35]



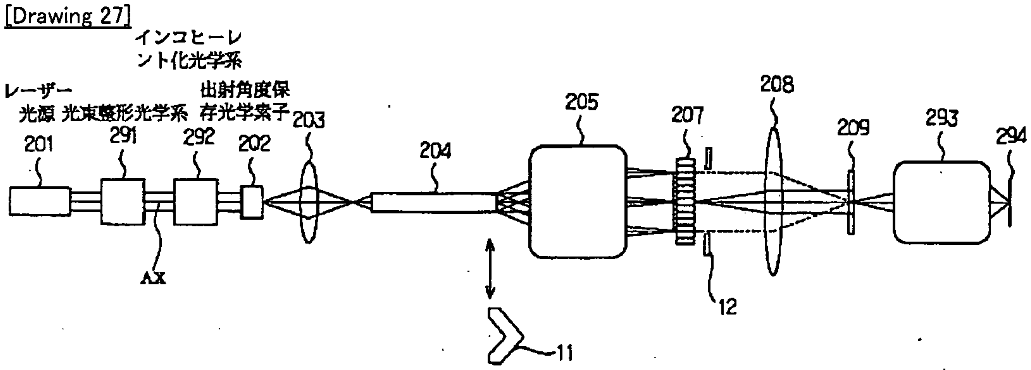
[Drawing 36]



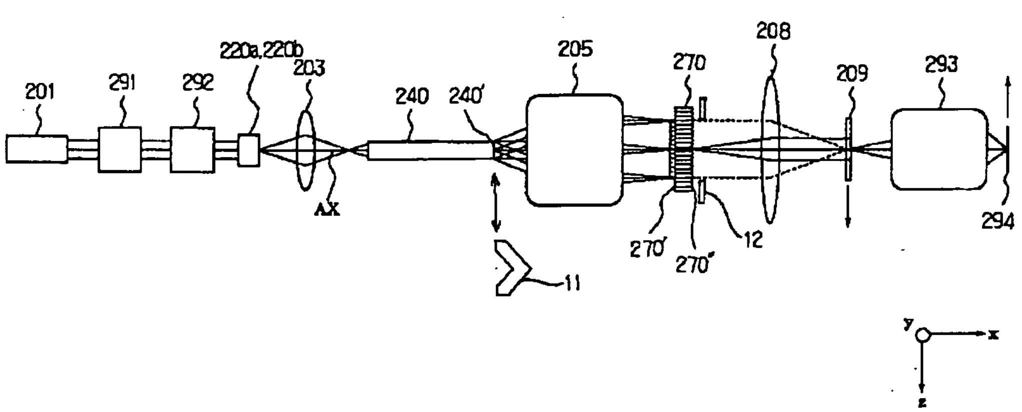
[Drawing 24]



[Drawing 27]



[Drawing 31]



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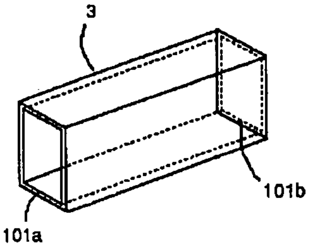
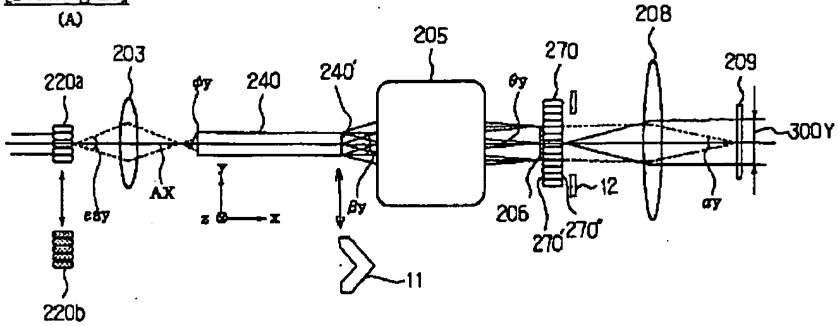
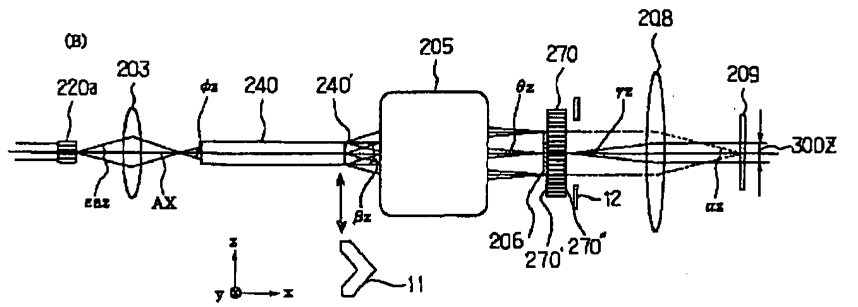
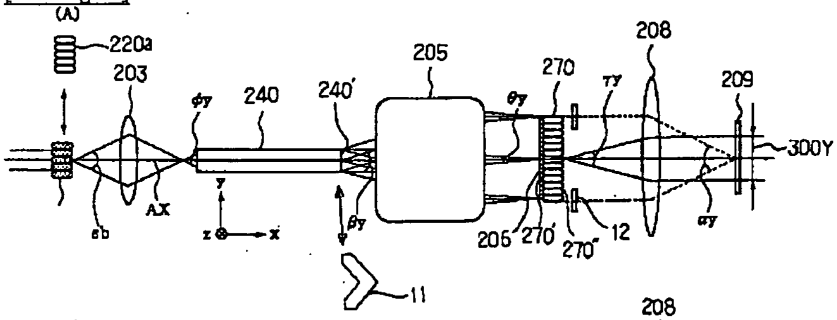


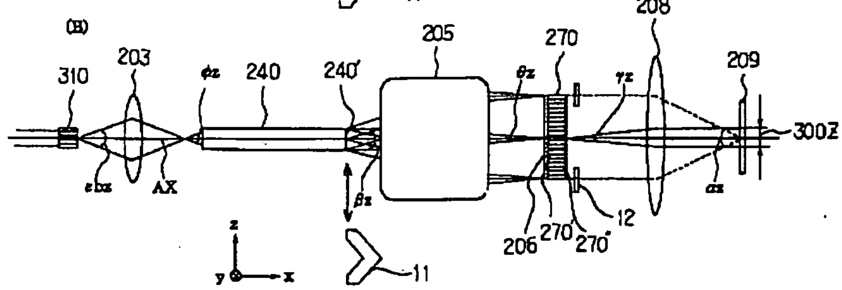
[Drawing 28]



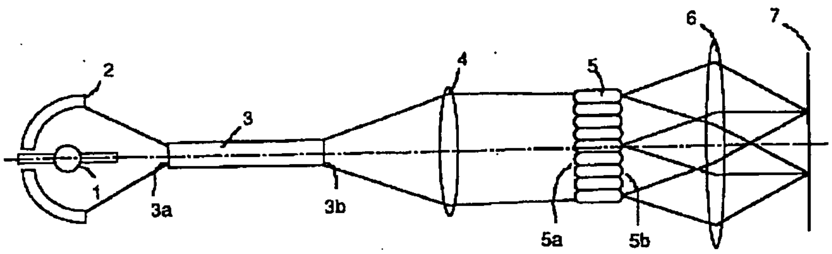


[Drawing 29]

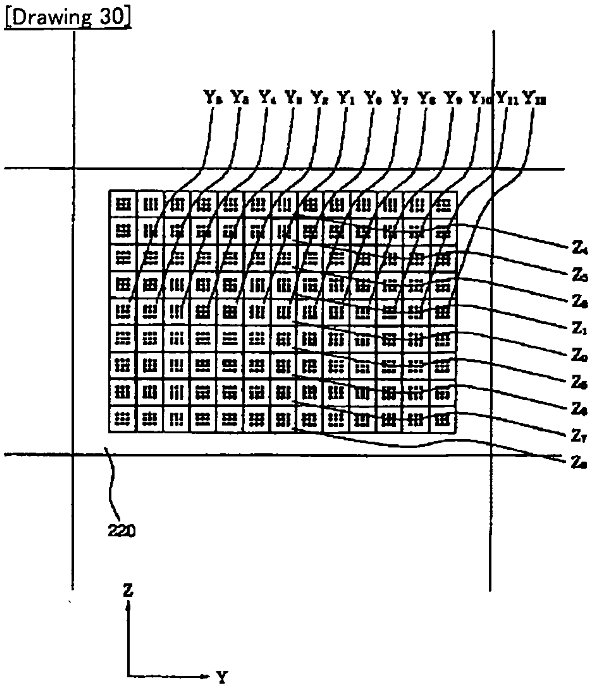




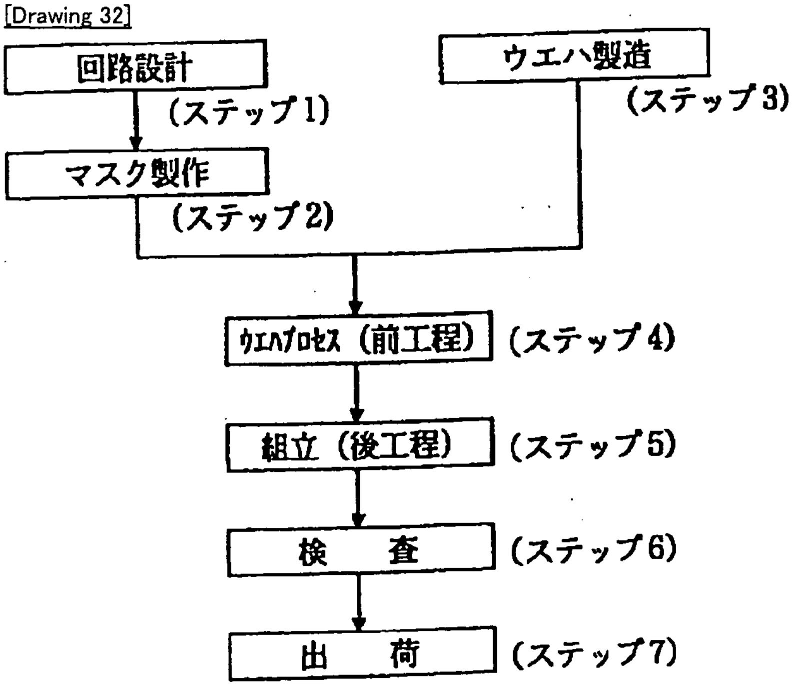
[Drawing 34]



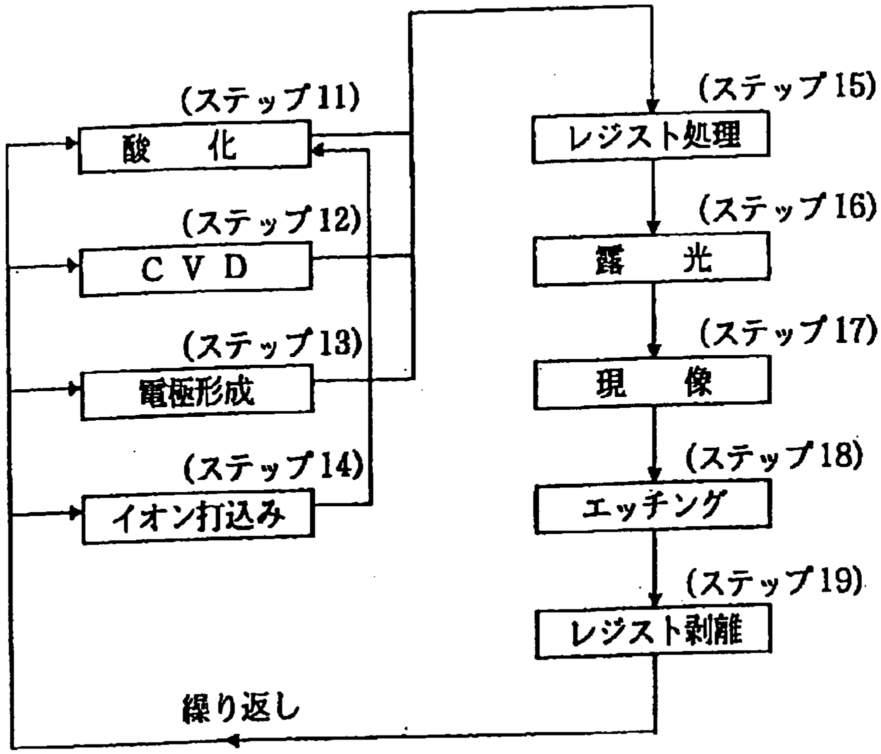
[Drawing 30]



[Drawing 32]



[Drawing 33]



[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette]Printing of amendment by regulation of Patent Law Article 17 of 2
[Section Type] The 2nd Type of the part VII gate
[Publication date]Heisei 13(2001) April 13 (2001.4.13)

[Publication No.]JP,11-54426,A
[Date of Publication]Heisei 11(1999) February 26 (1999.2.26)
[Annual volume number] Publication of patent applications 11-545
[Application number]Japanese Patent Application No. 9-221948
[The 7th edition of International Patent Classification]

H01L 21/027

G03F 7/20 521
[FI]

H01L 21/30 515 D

G03F 7/20 521

H01L 21/30 503 Z
[Written Amendment]
[Filing date]Heisei 11(1999) December 2 (1999.12.2)
[Amendment 1]
[Document to be Amended]Description
[Item(s) to be Amended]Claims
[Method of Amendment]Change
[Proposed Amendment]
[Claim(s)]
[Claim 1]A light source.
A condensing optical system which condenses light flux from this light source.
A light flux mixing means which mixes and ejects light flux from this condensing optical system, a multi luminous flux generator which generates much partial luminous flux using an outgoing beam from this light flux mixing means, and an irradiation means which irradiates with an irradiated plane where light flux from this multi luminous flux generator is piled up.
A light flux adjustment device which is the lighting system provided with the above and adjusts luminous energy distribution in an entrance plane of this multi luminous flux generator near the emission face of this light flux mixing means was provided.

[Claim 2]A lighting system of Claim 1 having set up an optical system arranged between said light flux mixing means and said multi luminous flux generator, and become approximately conjugate according to this optical system about an emission face of this light flux mixing means, and an entrance plane of this multi luminous flux generator.
[Claim 3]Claim 1, wherein said light flux mixing means has an optical pipe, or a lighting system of Claim 2.
[Claim 4]Claim 1 provided with an optical member which said light flux adjustment device has a concave conic surface in the light incidence face side, and has a convex conic surface in the light emitting surface side, Claim 2, or a lighting system of Claim 3.
[Claim 5]Claim 1 provided with an optical member which said light flux adjustment device has a concave polygonal-pyramid side in the light incidence face side, and has a convex polygonal-pyramid side in the light emitting surface side, Claim 2, or a lighting system of Claim 3.
[Claim 6]Claim 1 provided with an optical member which said light flux adjustment device has a polygonal-pyramid side of a concave surface which cut the neighborhood of a vertex in respect of being level to an optic axis in the light incidence face side, and has a polygonal-pyramid side of a convex which cut the neighborhood of a vertex in respect of being level to an optic axis in the light emitting surface side, Claim 2, or a lighting system of Claim 3.
[Claim 7]Claim 1, wherein said light flux adjustment device has two diffraction optical elements which have zona-orbicularis-like phase distribution, Claim 2, or a lighting system of Claim 3.
[Claim 8]Said light flux adjustment device has the substrate which provided a diffraction optical element in the whole surface, The surface integral rate of this diffraction optical element is carried out to many fields on this whole surface, and a diffraction optical element of each field is formed from a linear shape pattern, Claim 1 the diffraction directions of light flux by a diffraction optical element of each field differing mutually, and forming strong light intensity distribution in a discrete position on said multi luminous flux

generator [else], Claim 2, or a lighting system of Claim 3.
[Claim 9]Claim 1 having provided two or more light flux adjustment devices in which it was made for luminous energy distribution on an entrance plane of said multi luminous flux generator to differ, and having set up one of light flux adjustment devices of this plurality selectable into an optical path thru/or a lighting system of Claim 8 given in any 1 clause.
[Claim 10]Claim 1, wherein said multi luminous flux generator has an eye of a fly thru/or a lighting system of Claim 9 given in any 1 clause.
[Claim 11]Claim 1 having established a diaphragm from which aperture shape differs according to a kind of said light flux adjustment device exchangeable near the emission face of said multi luminous flux generator thru/or a lighting system of Claim 10 given in any 1 clause.
[Claim 12]A projection aligner projecting a pattern of a reticle on an exposed substrate according to a projection optical system using a lighting system of Claim 1 thru/or Claim 11 given in any 1 clause.
[Claim 13]A pattern of a reticle is projected on an exposed substrate according to a projection optical system using a lighting system of Claim 1 thru/or Claim 11 given in any 1 clause, A projection aligner exposing this exposed substrate by a pattern of this reticle by synchronizing both sides of this reticle and this exposed substrate with an optic axis and a perpendicular direction of this projection optical system with a velocity ratio made equivalent to projecting magnification of this projection optical system, and scanning them.
[Claim 14]A manufacturing method of a device including a stage which exposes a wafer by a circuit pattern of a reticle using a projection aligner of Claim 12 or Claim 13, and a stage of developing a this exposed wafer.
[Amendment 2]
[Document to be Amended]Description
[Item(s) to be Amended]0026
[Method of Amendment]Change
[Proposed Amendment]
[0026]
[Means for solving problem]The condensing optical system in which the lighting system of invention of Claim 1 condenses the light flux from a light source and this light source, The light flux mixing means which mixes and ejects the light flux from this condensing optical system, and the multi luminous flux generator which generates much partial luminous flux using the outgoing beam from this light flux mixing means, It is characterized by providing the light flux adjustment device which adjusts the luminous energy distribution in the entrance plane of this multi luminous flux generator near the emission face of this light flux mixing means in the lighting system which has an irradiation means which irradiates with an irradiated plane where the light flux from this multi luminous flux generator is piled up.
[Amendment 3]
[Document to be Amended]Description
[Item(s) to be Amended]0027
[Method of Amendment]Change
[Proposed Amendment]
[0027]It is characterized by having set up invention of Claim 2 the optical system arranged between said light flux mixing means and said multi luminous flux generator, and become approximately conjugate according to this optical system in invention of Claim 1, about the emission face of this light flux mixing means, and the entrance plane of this multi luminous flux generator. Invention of Claim 3 is characterized by said light flux mixing means having an optical pipe in Claim 1 or invention of 2.It is characterized by providing invention of Claim 4 with the optical member which said light flux adjustment device has a concave conic surface in the light incidence face side, and has a convex conic surface in the light emitting surface side in invention of Claim 1, 2, or 3. It is characterized by providing invention of Claim 5 with the optical member which said light flux adjustment device has a concave polygonal-pyramid side in the light incidence face side, and has a convex polygonal-pyramid side in the light emitting surface side in invention of Claim 1, 2, or 3.It is characterized by providing invention of Claim 6 with the optical member which said light flux adjustment device has a polygonal-pyramid side of the concave surface which cut the neighborhood of a vertex in respect of being level to an optic axis in the light incidence face side in invention of Claim 1, 2, or 3, and has a polygonal-pyramid side of the convex which cut the neighborhood of a vertex in respect of being level to an optic axis in the light emitting surface side. As for invention of Claim 7, in invention of Claim 1, 2, or 3, said light flux adjustment device is characterized by having two diffraction optical elements which have zona-orbicularis-like phase distribution. Invention of Claim 8 has the substrate with which said light flux adjustment device provided the diffraction optical element in the whole surface in invention of Claim 1, 2, or 3,The surface integral rate of this diffraction optical element is carried out to many fields on this whole surface, and the diffraction optical element of each field is formed from the linear shape pattern, The diffraction directions of the light flux by the diffraction optical element of each field differ mutually, and it is characterized by forming strong light intensity distribution in the discrete position on said multi luminous flux generator [else]. It is characterized by invention of Claim 9 having provided two or more light flux adjustment devices in which it was made for the luminous energy distribution on the entrance plane of said multi luminous flux generator to differ in invention of any 1 clause of 8 from Claim 1, and having set up one of the light flux adjustment devices of this plurality selectable into an optical path.Invention of Claim 10 is characterized by said multi luminous flux generator having an eye of a fly in invention of any 1 clause of 9 from Claim 1. Invention of Claim 11 is characterized by having established the diaphragm from which aperture shape differs in invention of any 1 clause of 10 according to the kind of said light flux adjustment device near the emission face of said multi luminous flux generator from Claim 1 exchangeable.
[Amendment 4]
[Document to be Amended]Description
[Item(s) to be Amended]0028
[Method of Amendment]Change
[Proposed Amendment]
[0028]It is characterized by the projection aligner of invention of Claim 12 projecting the pattern of a reticle on an exposed substrate according to a projection optical system using the lighting system of 11 given in any 1 clause from Claim 1. The projection aligner of

invention of Claim 13 projects the pattern of a reticle on an exposed substrate according to a projection optical system using the lighting system of 11 given in any 1 clause from Claim 1. It is characterized by exposing this exposed substrate by the pattern of this reticle by synchronizing the both sides of this reticle and this exposed substrate with the optic axis and perpendicular direction of this projection optical system with the velocity ratio made equivalent to the projecting magnification of this projection optical system, and scanning them.
[Amendment 5]
[Document to be Amended]Description
[Item(s) to be Amended]0029
[Method of Amendment]Change
[Proposed Amendment]
[0029]It is characterized by the manufacturing method of the device of invention of Claim 14 including the stage which exposes a wafer by the circuit pattern of a reticle using Claim 12 or the projection aligner of 13, and the stage of developing the this exposed wafer.
[Amendment 6]
[Document to be Amended]Description
[Item(s) to be Amended]0077
[Method of Amendment]Change
[Proposed Amendment]
[0077]The light flux adjustment device 11g has the two diffraction optical elements 111 and 112. The composition became an entrance plane of the plane-parallel plate 111a, and an emission face of the plane-parallel plate 112a from the blazed ****** diffraction grating element.
[Amendment 7]
[Document to be Amended]Description
[Item(s) to be Amended]0124
[Method of Amendment]Change
[Proposed Amendment]
[0124]The light flux made incoherent from the incoherent-ized optical system 292 enters into the emitting angle degree preservation optical element 202. By the procedure described using drawing 22 thru/or drawing 26 below, the light flux emitted from each infinitesimal area (microlens) of the wavefront-splitting type integrator 207 superimposes the mask 209 according to the condensing optical system 208, and illuminates. Uniform illumination of the mask 209 is carried out so that uniform illuminance distribution may be acquired all over the circuit pattern which should project the mask 209. And projection imaging of the circuit pattern formed on the mask 209 is carried out by the projection optical system 293 on the wafer 294, and exposure of the circuit pattern (image) to the photosensitive materials of the wafer 294 is performed. The wafer 294 is being fixed to the unillustrated XYZ movable stage by the vacuum absorption method etc., a XYZ movable stage has a function which carries out parallel translation before and after the four directions of space, and the movement is controlled by length measuring machines, such as an unillustrated laser interferometer. Since such technology is well-known technology, detailed explanation is omitted.

[Translation done.]

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審査請求　未請求　請求項の数14　ＦＤ　（全 21 頁）

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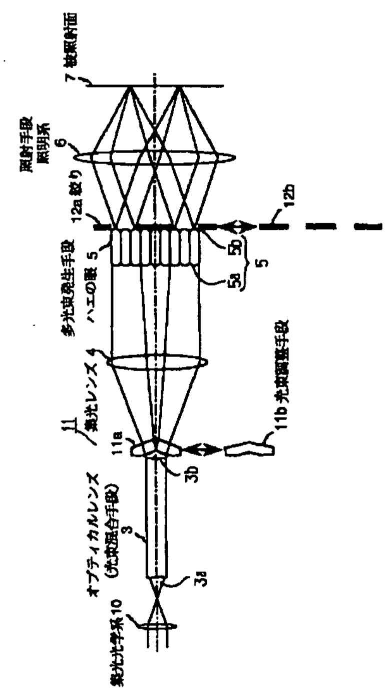
(54)【発明の名称】　照明装置及びそれを用いた投影露光装置

(57)【要約】
【課題】　通常照明と変形種名の切り替えが簡易でかつ光の利用効率が高く、容易に実現し得る照明装置及びそれを用いた投影露光装置を得ること。
【解決手段】　光源と、該光源からの光束を集光する集光光学系と、該集光光学系からの光束を混合して射出する光束混合手段と、該光束混合手段からの出射光束を用いて多数の部分光束を発生させる多光束発生手段と、該多光束発生手段からの光束を重ね合わせた状態で被照射面を照射する照射手段と、を有する照明装置において、該光束混合手段の出射面近傍に光束調整手段を設け、該多光束発生手段の入射面での光量分布を調整可能に構成していること。



【特許請求の範囲】
【請求項１】　光源と、該光源からの光束を集光する集光光学系と、該集光光学系からの光束を混合して射出する光束混合手段と、該光束混合手段からの出射光束を用いて多数の部分光束を発生させる多光束発生手段と、該多光束発生手段からの光束を重ね合わせた状態で被照射面を照射する照射手段と、を有する照明装置において、該光束混合手段の出射面近傍に光束調整手段を設け、該多光束発生手段の入射面での光量分布を調整可能に構成していること
【請求項２】　前記光束混合手段と前記多光束発生手段の間には光学系が配置されており、該光学系により該光束混合手段の出射面と、該多光束発生手段の入射面とを略共役になるよう設定していることを特徴とする請求項１、又は２の照明装置。
【請求項３】　前記光束混合手段はオプティカルパイプを有していることを特徴とする請求項１、又は２の照明装置。
【請求項４】　前記光束調整手段は、入射面側が凹面の、出射面側が凸面の円錐面を持つ光学部材からなることを特徴とする請求項１、２、又は３の照明装置。
【請求項５】　前記光束調整手段は、入射面側が凹面の、出射面側が凸面の多角錐面を持つ光学部材からなることを特徴とする請求項１、２、又は３の照明装置。
【請求項６】　前記光束調整手段は、入射面側が凹面の、出射面側が凸面の多角錐面の頂点を光軸に水平な面で切断した平面を有する光学部材からなることを特徴とする請求項１、２、又は３の照明装置。
【請求項７】　前記光束調整手段は、輪帯状の位相分布を有する回折光学素子を２つ有していることを特徴とする請求項１、２、又は３の照明装置。
【請求項８】　前記光束調整手段は一面に回折光学素子を設けた基板を有しており、該回折光学素子は該一面上の多数の領域に面積分割されており、かつ各々の領域の回折光学素子は直線状のパターンから形成されており、また各々の領域の回折光学素子による光束の回折方向が互いに異なっており、前記多光束発生手段上の離散的な位置に他に比べて強い光強度分布を形成していることを特徴とする請求項１、２、又は３の照明装置。
【請求項９】　前記多光束発生手段の入射面上での光量分布が異なるようにした光束調整手段を複数設け、該複数の光束調整手段のうちの１つを光路中に選択可能に設定していることを特徴とする請求項１～８のいずれか１項記載の照明装置。
【請求項１０】　前記多光束発生手段はハエの目を有していることを特徴とする請求項１～９のいずれか１項記載の照明装置。
【請求項１１】　前記多光束発生手段の出射面近傍には前記光束調整手段の種類に応じて開口形状が異なる絞りを交換可能に設けていることを特徴とする請求項１～１０のいずれか１項記載の照明装置。
【請求項１２】　請求項１から１１のいずれか１項記載の照明装置を用いて被照射面に設けた物体面上のパターンを投影光学系により露光基板に投影露光していることを特徴とする投影露光装置。
【請求項１３】　請求項１から１１のいずれか１項記載の照明装置を用いて被照射面に設けた物体面上のパターンを投影光学系により露光基板に、該物体と該露光基板の双方を該投影光学系の光軸と垂直方向に該投影光学系の投影倍率に対応させた速度比で同期させて走査して露光することを特徴とする投影露光装置。
【請求項１４】　請求項１２又は１３の投影露光装置を用いて物体面上のパターンを投影光学系により露光基板上に投影露光した後、該露光基板を現像処理してデバイスを製造することを特徴とするデバイスの製造方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は照明装置及びそれを用いた投影露光装置及びデバイスの製造方法に関し、具体的には半導体素子等のデバイスの製造装置において、レチクル面上のパターンを適切に照明し、高い解像力が容易に得られるようにした例えばステップアンドリピート方式やステップアンドスキャン方式の投影露光装置に好適なものである。
【０００２】
【従来の技術】一般に半導体素子等のデバイス製造用の露光装置に使用される照明装置には、高解像力化を図るためにマスク面（レチクル面）における照度ムラの除去が強く要求されている。この要求と、集光効率の向上を図った照明装置が、本出願人は例えば特開平1-000913号公報において提案している。
【０００３】図３４は同公報で提案している照明装置の要部概略図である。
【０００４】図中１は光源で、超高圧水銀ランプ等からなっている。２は集光手段で楕円ミラー等からなり、該楕円ミラー２の第１焦点付近に光源１が配置されている。３は光束混合手段で所定形状のオプティカルパイプより成り、該オプティカルパイプ３の入射面３ａは楕円ミラー２の第２焦点付近配置されている。４は集光レンズ、５は多光束発生手段であるハエの目であり、集光レンズ４はオプティカルパイプ３の出射端３ｂとハエの目５の入射面５ａとが略共役関係となるように設定している。またその際出射端３ｂを入射面５ａに所望の倍率で結像するよう集光レンズ４の光学諸定数を定めている。
【０００５】６は照射手段でコンデンサーレンズを含む構成からなり、ハエの目５の出射面５ｂからの光束を用いてマスクやレチクル面等が設定される被照射面７を照射している。
【０００６】その際ハエの目５を構成している素子レンズの集光点（後側焦点）を集光手段６の前側焦点に略一

致させ、被照射面７と集光手段６の後側焦点と略一致させるケーラー照明系を構成している。
【０００７】光束混合手段３であるオプティカルパイプは内側面による多重反射を利用して、１つの光束から多数の虚または実の集光点を形成するものであり、その原理を図３５～３７に示す。
【０００８】例えばオプティカルパイプを図３７に示す様な正方形断面を有する中空で、内面反射をする部材で構成されているとする。
【０００９】図３５はオプティカルパイプ３の入射面３０１ａの前側に光源像Ｓ０を持つ集光光束により虚の集光点が形成される様子を光軸に沿った断面で表したものである。
【００１０】光源像Ｓ０から入射する光束のうち、上方側面３０１ｃ、下方側面３０１ｄで一度も反射されない光束は、そのまま射出面３０１ｂから出射していく。
【００１１】上方側面３０１ｃでのみ１回反射される光束は、上方側面３０１ｃに関して集光点Ｓ０と共役な虚の集光点Ｓ１から供給されるように出射し、また下方側面３０１ｄでのみ１回反射される光束は、下方側面３０１ｄに関して集光点Ｓ０と共役な虚の集光点Ｓ－１　から供給されるように出射する。
【００１２】以下同様にして、下方側面３０１ｄで反射した後、上方側面３０１ｃで反射される光束は集光点Ｓ０から供給されるように出射し、上方側面３０１ｃで反射した後、下方側面３０１ｄで反射される光束は集光点Ｓ２から供給されるように出射する。
【００１３】従ってこのオプティカルパイプに入射する光源像Ｓ０を持つ光束は、側面での１回又は複数回の反射によって実質的に多数の光源像から供給されているように出射する。
【００１４】この結果、各側面での反射により出射面から見た集光点の様子は、図３６のように格子状に分布した多数の集光点からの光束によって出射面３０１ｂが照明されるようになり、これら多数の虚集光点の形成される面Ｓ　に実質的な面光源が形成されている。
【００１５】よってオプティカルパイプ３の出射端３０１ｂは略均一な照度分布を得ることができる。
【００１６】その均一の度合いはオプティカルパイプ３内での光束の反射回数によって定まるが、ここでは詳細な説明は省く。
【００１７】ハエの目５は複数の微小レンズのアレイよりなり、その出射面５ｂは２次光源面を形成している。
【００１８】既に説明したように、オプティカルパイプ３の出射面３０１ｂとハエの目５の入射面５ａは略共役に結ばれており、オプティカルパイプ３の出射面３０１ｂで既に略均一な照度分布を形成しているが、それをハエの目５に入射させ、照射手段６でケーラー照明で被照射面７を照射することにより、さらに均一な照度分布を被照射面上で達成している。
【００１９】ところで最近の半導体素子の集積度の向上に伴ない、投影露光装置の要求される解像力も年々高まりつつある。解像力を向上させるため、光源の短波長化か、位相シフト法の採用、変形照明法の採用等の種々の方法が研究開発されており、特に変形照明法は従来装置に対し大幅な変更を加える必要がなく、かつ従来のマスクパターンの変更が必要ないという利点を有している。
【００２０】変形照明法の代表的な例としては、照明光学系の、投影光学系の瞳と略共役な面において光束が通過する際に光束の通過位置が光軸から離間した４箇所に制限される、所謂４重極照明と称させる方法と、前記の照明光学系の面において光束の通過位置が光軸と同心の輪帯状に制限される、所謂輪対照明と称される方法の２つが特に一般的である。
【００２１】４重極照明は特に縦横の線から成るパターンについて、解像力の向上及び焦点深度の増大の効果が顕著であるが、斜め方向の線からなるパターンについてはむしろ変形照明をしない通常照明よりも悪化する欠点がある。
【００２２】一方輪帯照明は、解像力の向上および焦点深度増大の効果は４重極よりも顕著ではないが、パターンの方向に依存しない特徴を有している。
【００２３】変形照明法を利用した照明装置として特開平5-251308号公報では、光源手段とインテグレータとの間に平行光を輪帯状光束に変換する輪帯状光束変換手段を設けて、被照明面を均一に傾斜照明している。
【００２４】特開平5-283317号公報や特開平6-204114号公報では楕円鏡とオプティカルインテグレータとの間に入射光束を所定方向に偏向させる挿脱可能な光学素子を配置して、オプティカルインテグレータの入射面の光強度分布を変えて、被照射面を照明している。
【００２５】
【発明が解決しようとする課題】本発明は前述した照明装置を改良し、通常照明法と変形照明法の切り替えが容易で、かつ高い照明効率で被照射面を均一に照明することができ、高集積度のデバイスを容易に製造することができる照明装置及びそれを用いた投影露光装置、デバイスの製造方法の提供を目的とする。
【００２６】
【課題を解決するための手段】本発明の照明装置は
（１－１）光源と、該光源からの光束を集光する集光光学系と、該集光光学系からの光束を混合して射出する光束混合手段と、該光束混合手段からの出射光束を用いて多数の部分光束を発生させる多光束発生手段と、該多光束発生手段からの光束を重ね合わせた状態で被照射面を照射する照射手段と、を有する照明装置において、該光束混合手段の出射面近傍に光束調整手段を設け、該多光束発生手段の入射面での光量分布を調整可能に構成していることを特徴としている。
【００２７】特に、

（１－１－１）前記光束混合手段と前記多光束発生手段の間には光学系が配置されており、該光学系により該光束混合手段の出射面と、該多光束発生手段の入射面とを略共役になるよう設定していること。
（１－１－２）前記光束混合手段はオプティカルパイプを有していること。
（１－１－３）前記光束調整手段は、入射面側が凹面の、出射面側が凸面の円錐面を持つ光学部材からなること。
（１－１－４）前記光束調整手段は、入射面側が凹面の、出射面側が凸面の多角錐面を持つ光学部材からなること。
（１－１－５）前記光束調整手段は、入射面側が凹面の、出射面側が凸面の多角錐面の頂点を光軸に水平な面で切断した平面を有する光学部材からなること。
（１－１－６）前記光束調整手段は、輪帯状の位相分布を有する回折光学素子を２つ有していること。
（１－１－７）前記光束調整手段は一面に回折光学素子を設けた基板を有しており、該回折光学素子は該一面上の多数の領域に面積分割されており、かつ各々の領域の回折光学素子は直線状のパターンから形成されており、また各々の領域の回折光学素子による光束の回折方向が互いに異なっており、前記多光束発生手段上の離散的な位置に他に比べて強い光強度分布を形成していること。
（１－１－８）前記多光束発生手段の入射面上での光量分布が異なるようにした光束調整手段を複数設け、該複数の光束調整手段のうちの１つを光路中に選択可能に設定していること。
（１－１－９）前記多光束発生手段はハエの目を有していること。
（１－１－１０）前記多光束発生手段の出射面近傍には前記光束調整手段の種類に応じて開口形状が異なる絞りを交換可能に設けていること等を特徴としている。
【００２８】本発明の投影露光装置は構成（１－１）の照明装置を用いて、
（２－１）被照射面に設けた物体面上のパターンを投影光学系により露光基板に投影露光していることを特徴としている。
（２－２）被照射面に設けた物体面上のパターンを投影光学系により露光基板に該物体と該露光基板の双方を該投影光学系の光軸と垂直方向に該投影光学系の投影倍率に対応させた速度比で同期させて走査して露光することを特徴としている。
【００２９】本発明のデバイスの製造方法は構成（２－１）又は（２－２）の投影露光装置を用いて
（３－１）物体面上のパターン投影光学系により露光基板上に投影露光した後、該露光基板を現像処理してデバイスを製造することを特徴としている。
【００３０】
【発明の実施の形態】図１は本発明の照明装置の実施形態１の一部分の要部概略図、図２は本発明の照明装置を用いた投影露光装置の実施形態１の要部概略図である。
【００３１】本実施形態の投影露光装置はステップアンドリピート方式やステップアンドスキャン方式が適用可能である。
【００３２】図中、２０は光源であり、紫外線や遠紫外線などを放射するエキシマレーザや超高圧水銀灯等から成っている。光源２０を出射した光束は光束整形手段２１を経て所望の光束形状にした後、インコヒーレント化手段２２を経て干渉性の低い光束へ変換して、さらに出射角保存光学素子２３により、光源２０と投影露光装置の間の振動等による影響を排除した後、集光光学系１０に入射している。
【００３３】出射角保存光学素子２３からの光束は集光光学系１０で集光点を作った後、オプティカルパイプ（光束混合手段）３の入射面３ａに入射する。オプティカルパイプ３の出射端（出射面）３ｂ近傍には、不図示の駆動機構により着脱交換可能な光束調整手段１１（１１ａ　１１ｂ）が設けられており、オプティカルパイプ３を出射する光束分布に対して所望の規制を加えている。
【００３４】光束調整手段１１（１１ａ、１１ｂ）は例えば図３（Ａ）、（Ｂ）に示すように入射面側に凹の、出射面側に凸の円錐面を有するプリズム部材（光学部材）より成っており光束調整手段１１ａ、１１ｂにおいてはその頂角が異なっており、光束調整手段１１ａの方が光束調整手段１１ｂに比べて角度が小さい、すなわちより鋭い凸の形状となっている。光束調整手段１１ａの方が外径の大きな輪帯、光束調整手段１１ｂの方が外径の小さな輪帯の有効光源を後述する多光束発生手段５の入射面５ａに形成している。４は集光レンズであり、光束調整手段１１からの高速をハエの目レンズより成る多光束発生手段５の入射面５ａに集光している。
【００３５】集光レンズ４は光束混合手段３の出射面３ｂを多光束発生手段５の入射面５ａに所定の倍率で結像させ、双方が互いに略共役関係となるようにしている。
【００３６】ハエの目５の出射面５ｂ近傍は２次光源となっており、そこには不要光を遮光して所望形状の有効光源が形状に整形されている。１２は絞りであり、多光束発生手段５の出射面５ｂ近傍に、駆動機構により着脱交換可能に設けられている。絞り１２は複数の絞り（１２ａ、１２ｂ）を有している。
【００３７】絞り１２ａ、１２ｂは例えば、図４（Ａ）、（Ｂ）に示す開口部を有している。図４において斜線部分が遮光部である。
【００３８】６は照射手段であり、ハエの目５の出射面５ｂからの光束のうち、絞り１２の開口部を通過した光束を集光して被照射面（レチクル）７をケーラー照明している。
【００３９】２４は投影光学系であり、レチクル（マス

ク）7に描かれたパターンを露光基板（ウエハ）25に投影している。

【0040】本実施形態の投影露光装置においては、光束調整手段11a、11b等を挿入あるいは他の光束調整手段と交換することで輪帯照明、4重極照明等の変形照明に変更となっている。

【0041】その際必要に応じ絞り12を多光束発生手段5の出射面5b近傍に挿入することにより、不要光を遮光し所望の有効光源形状をより正確に形成するようにしている。

【0042】次に本実施形態の構成のうち前述した構成以外の特徴について説明する。

【0043】光束調整手段11によりハエの目5の入射面5aで形成される照度分布は、光束調整手段11の形状、光束調整手段11と集光レンズ4及びハエの目5の入射面5aの光学的配置、また集光レンズ5の収差等によって異なる。

【0044】光束調整手段11として図3（A）に示す光束調整手段11aを使用した場合には、例えば図5に示すようにハエの目5の入射面5a上に輪帯状の照度分布を形成し、かつそれらの強度が暗部と明部が非常に急激な変化を有する場合がある。

【0045】図5中の斜線部分が光が照射されている部分であり、そのXX′断面での光強度を下に示している。図5に示すように、この場合は所望の有効光源分布に対する不要光がほとんど生じないので、前述の絞り12aは不要となる。

【0046】これに対して照明系によっては図6に示すように輪帯の光強度の断面がガウス分布の様に上部及び下部がダレる場合がある。その場合は図4（A）に示す絞り12aを用いることで不要光を遮光している。

【0047】図7の斜線部は絞り12aを用いたときの遮光されずに有効光源分布の形成に寄与する部分を示している。

【0048】図8は図1において光束調整手段11aを光束調整手段11bに交換した場合の説明図である。

【0049】この場合も前述したのと同様に図9に示すように、ハエの目5の入射面5aの輪帯状の照度分布の明部と暗部が非常に急激な変化をする場合がある。この場合は絞り12bは不要である。これに対して、ハエの目5の入射面5aでの強度分布が図10に示すような場合にはやはり絞り12bを用いて不要光を遮光している。図11の斜線部は絞り12bを用いたときの遮光されず有効光源分布の形成に寄与する部分を示している。

【0050】以上は輪帯照明を形成する場合を述べたが、同様にして光束調整手段11を切り替えることにより4重極等の変形照明にも対応可能である。

【0051】図3（C）に示す光束調整手段11cは4重極照明を形成するための光束調整手段の外径であり、入射面側に凹の、出射面側に凸の4角錐面形状を有するプリズム部材より成っている。

【0052】これによりハエの目5の入射面5aには例えば図12に示す斜線部分にのみ光束が入射する。この際絞りも図4（C）に示す絞り12cに変更して、図13に斜線を示した部分のみで有効光源を形成し、所望の有効光源を形成している。尚図12の下の図及び図13は、図12の上の図のAA′断面での強度分布を示している。

【0053】この場合は輪帯照明の説明の中で既に述べたように、ハエの目5の入射面5a側での照度分布は明部と暗部で急激な変化を有する場合であるが、それがガウス分布の様な場合については前述したのと同じなので説明を省く。

【0054】また4重極の離散的な強度分布の光軸からの位置については、輪帯照明のプリズム部材と同様、4角錐の頂角を調整することで、任意の位置に調整可能である。

【0055】図3（D）に示す光束調整手段11dは4重極ほど離散的に強度分布が強い有効光源ではなく、4重極の他の部分にも弱いながらも強度分布を有する有効光源を形成するための光束調整手段の外径の説明図である。

【0056】図3（D）の光束調整手段は図3（C）の光束調整手段11cのプリズム部材の凹と凸の頂点を平にしたものである。これによりハエの目5に入射する光束の強度分布は図14に示した様になる。

【0057】本実施形態では以上説明したように、光束混合手段3と多光束発生手段5を用いた照明装置において、所望の有効光源分布に対応した光束調整手段11を光束混合手段3の直後に挿入するだけで、他の光学部材を特に調整する必要なく、効率の高い変形照明を可能としている。

【0058】また、光束調節手段の挿入により、光束混合手段と集光レンズ間の光路長が変わるが、そのために照明系に不都合が生じる場合は、光束調節手段を用いない通常照明時にも、光束調節手段と略等しい光路長の平行平板を挿入しておき、変形照明時には、それと光束調節手段を交換するように構成してもよい。

【0059】図15は本発明の照明装置の実施形態2の一部分の要部概略図である。

【0060】本実施形態は図1の実施形態1に比べて光束調整手段11（11e、11f）として、所定形状のプリズム部材の代わりに平行平面板111aの表裏面に回折光学素子111、112を設けて構成した点が異なっており、その他の構成は同じである。

【0061】図中、図1で示した要素と同一要素には同符番を付している。

【0062】本実施形態は実施形態1と同様、光束混合手段オプティカルパイプ3の出射端3b近傍に着脱交換可能に光束調整手段11e、11fが設けられており、

また同様にハエの目５の出射面５ｂ近傍には着脱交換可能な絞り１２ｅ、１２ｆが設けられている。

【００６３】光束調整手段１１ｅ、１１ｆは図１６に示すように平行平面板１１１ａの表裏面に各々回折光学素子１１１、１１２を設けて構成している。

【００６４】図１６は光束調整手段１１ｅの光軸Ｌａを含んだ断面での概略図と、その一部の拡大図を示している。光束調整手段１１ｅのブレーズド形状は図中の拡大図に示したとおりである。すなわち回折光学素子１１１は垂直に光が入射した場合光軸と反対方向に光を回折させる作用を有している。一方回折光学素子１１２は垂直に光が入射した場合光軸Ｌａ側に光を回折させる作用を有している。

【００６５】光束調整手段１１ｅが例えば輪帯照明を形成する光束調整手段であるとすると、回折光学素子１１１、１１２の位相分布は図１７に示すように光軸を中心とした同心円状のパターンから構成される回折光学素子となる。

【００６６】また光束調整手段１１ｅが４重極照明を形成する光束調整手段であるとすると、回折光学素子１１１、１１２の位相分布は図１８に示すように、直線状のパターンを隣接するパターンと直交する様に配置した回折光学素子となる。

【００６７】また光束調整手段１１ｅが図１４に示した有効光源分布を形成する光束調整手段であるとすると、回折光学素子１１１、１１２は図１９に示すように、図１８の直線状の回折光学格子で構成されたものから、光軸Ｌａを含む中心部分を回折作用を持たないようにした形状の回折光学素子となる。

【００６８】本実施形態ではこれらの回折光学素子でハエの目５へ入射する光束の分布を調整することで各種変形照明を効率よく形成している。又実施形態１で述べたようにハエの目５の入射面５ａ上での強度分布がガウス分布のようなスロープを持っている場合は、ハエの目５出射面５ｂ近傍に絞り１２を設け、それを光束調整手段１１の変更に合わせて変更させて、所望の形状の有効光源分布を形成している。

【００６９】以上説明したように、実施形態２においても光束混合手段３と多光束発生手段５を用いた照明装置において、所望の有効光源分布に対応した光束調整手段１１を光束混合手段３の直後に挿入するだけで、他の光学部材を特に調整する必要なく、効率の高い変形照明を可能としている。

【００７０】さらに実施形態１の光束調整手段１１はプリズム部材で構成されているため、所望された有効光源分布の場合においてはそれに基づいてプリズム部材を加工していた。これに対して本実施形態においては回折光学素子を用いて光束調整手段を構成しているので、回折光学素子としての機能を有するための微細加工が許す範囲であればいかなる光束調整手段も容易に作成可能である。

【００７１】その際図１６に示した様に、光リソグラフィー技術を使用したバイナリ光学素子として形成することが効率や製造誤差等の点から望ましく、また効率を考えると８レベル以上のバイナリ光学素子とすることが望ましい。

【００７２】図２０は本発明の照明装置の実施形態３の一部分の要部概略図である。

【００７３】本実施形態は図１５の実施形態２に比べて、光束調整手段１１として平行平面板１１１ａ（１１１ｂ）の一面に回折光学素子１１１（１１２）を設けた２つの部材１１１ｂ、１１２を対向配置して構成している点が異なっており、その他の構成は同じである。

【００７４】図中、図１５で示した要素と同一要素には同符番を付している。

【００７５】本実施形態は実施形態２と同様、光束混合手段（オプティカルパイプ）３の出射端３ｂ近傍に着脱交換可能に光束調整手段１１ｇ、１１ｈが設けられており、また同様にハエの目５の出射面５ｂ近傍には着脱交換可能な絞り１２ｇ、１２ｈが設けられている。

【００７６】光束調整手段１１ｇ、１１ｈは各々、図２１に示すように平行平面板１１１ａ、１１２ａの一面に回折光学素子１１１、１１２を設けた部材１１１ｂ、１１２ｂを対向配置して構成している。図２１は光束調整手段１１ｇの光軸Ｌａを含んだ断面での概略図と、その一部の拡大図を示している。

【００７７】光束調整手段１１ｇは２つの回折光学素子１１１、１１２を有している。その構成は平行平面板１１ａの入射面と平行平面板１１２ａの出射面にブレーズドされた回折格子素子より成っている。

【００７８】その他の作用や構成は実施形態２と同様であるので説明を省く。

【００７９】以上説明したように、実施形態３においても光束混合手段３と多光束発生手段５を用いた照明装置において、所望の有効光源分布に対応した光束調整手段１１を光束混合手段３の直後に挿入するだけで、他の光学部材を特に調整する必要なく、効率の高い変形照明を可能としている。

【００８０】また実施形態２と同様に回折光学素子を用いて光束調整手段を構成しているので、回折光学素子としての機能を有するための微細加工が許す範囲であれば、いかなる光束調整手段も容易に作成可能であり、その際、回折光学素子を光リソグラフィー技術を使用したバイナリ光学素子として形成することが効率や製造誤差等の点から望ましく、また効率を考えると８レベル以上のバイナリ光学素子とすることが望ましい。

【００８１】さらに本実施形態では回折光学素子１１１、１１２の２つの平行平面板１１１ａ、１１２ａ部材に分離して構成し、その分、硝材厚を削減している。

【００８２】図２２は本発明の照明装置の実施形態４の

要部概略図で、ＬＳＩやＶＬＳＩ等の半導体チップや、ＣＣＤ，磁気センサ、液晶素子等のデバイスを製造する、ステップ＆リピート型やステップ＆スキャン型の投影露光装置に用いる照明装置の概略図である。以下実施形態４においては前述した各実施形態と異なっている構成を中心に説明する。

【００８３】図２２において、２０１はＡｒＦエキシマレーザ（波長約193nm ）やＫｒＦエキシマレーザ（波長約248nm ）等のレーザ光源、２０２は入射光が変位してもそれから出射する光束の出射角が変化しない（保存する）出射角度保存光学素子、２０３は集光光学系、２０４は光束混合手段、２０５はズーム光学系、２０７は多光束発生手段、２０８は集光光学系、２０９はデバイスパターンが形成されたマスク（レチクル）等の被照明物体を示す。又、ＡＸは照明装置の光軸を示す。

【００８４】１１は光束調整手段であり、前述した各実施形態と同様の構成が適用可能となっている。１２は絞りであり、前述した各実施形態と同様の構成が適用可能となっている。

【００８５】集光光学系２０８及びズーム光学系２０５は、基本的に複数のレンズ素子より成り、場合によっては光路を折り曲げるためのミラーを少なくとも一枚有する。又、レンズ素子が一枚の場合もある。特にズーム光学系の複数のレンズ素子の内の複数のレンズ素子は不図示の駆動機構により光軸ＡＸに沿って移動するよう構成してあり、複数のレンズ素子を光軸方向に所定の関係で動かすことにより、結像面の位置を固定しつつ結像倍率を変えるようにしてある。

【００８６】光束混合手段２０４は、例えば、単一の光パイプ又は複数個の光パイプを束ねた光パイプ束である。光パイプは、レーザー光源２０１からのレーザー光に対して透過率の良い硝材（石英や蛍石）を用いた多角柱又は頂点側を切断した多角錐より成るガラス棒や、３枚以上の平面鏡を各々の反射面を対面させて筒状に構成したカレイドスコープ（万華鏡）のような中空の光学素子から成る。この中空の光学素子も外形は多角柱又は頂点側を切断した多角錐となる。光パイプの側面にある反射面（ガラス棒の場合は空気との界面、中空光学素子の場合は内側の反射面）は平坦で高い反射率を有する。光束混合手段２０４は、その側面の反射面により入射光の少なくとも一部を反射しつつ伝播させて入射光の複数の光線を混ぜ合わせることにより、その光出射面２０４′に又はその近傍に強度分布が均一な面光源（光）を形成する。以下、光束混合手段２０４及びこれと同じ機能を有するものを「内面反射型インテグレータ」ともいう。

【００８７】多光束発生手段２０７は、複数の微小レンズより成るハエの目レンズや光ファイバー束等からなり、その光入射面２０７′に入射した入射光の波面を複数の部分に分割してその光射出面２０７″又はその近傍に複数の点光源から成る面光源（光）を形成している。複数の点光源からの光は後段の光学系を介して互いに重なり合い所定の平面に強度分布が均一な面光源（光）を形成する。以下、多光束発生手段２０７及びこれと同じ機能を有するものを「波面分割型インテグレータ」ともいう。

【００８８】レーザ光源２０１から射出したレーザ光は不図示のミラーやリレーレンズから成る光束引き回し光学系を経て出射出角度保存光学素子２０２に入射する。出射角度保存光学素子２０２は図２３（Ａ）に示すようにアパーチャ２２１とレンズ系２２２から構成されており、入射光束が光軸ＡＸに直交する方向にある範囲内で変位して光束２２７から光束２２８の状態に変化しても、出射角度保存光学素子２０２から射出される光束の出射角度（開き角）ϕが一定である性質を有する。

【００８９】又、出射角度保存光学素子２０２は、図２３（Ｂ）に示すような複数の、微小レンズ２２３より成るハエの目レンズにより構成しても良い。この場合は出射角度ϕは微小レンズの形状に依存する。図２３（Ｂ）の光学素子２０２も、入射光束が光軸ＡＸに直交する方向にある範囲内で変位して光束２２７から光束２２８の状態に変化しても、出射角度保存光学素子２０２から出射する光束の出射角度（開き角）ϕが一定である。尚、ハエの眼レンズ以外の波面分割型インテグレータが、出射角度保存光学素子２０２として適用可能である。

【００９０】出射角度保存光学素子２０２から出射角度ϕで射出された光束（ハエの眼レンズの場合は多光束）は、集光光学系２０３により内面反射型インテグレータの手前に一旦集光され、その後内面反射型インテグレータ２０４内に発散状態で入射する。内面反射型インテグレータ２０４に入射した発散光束は、その内面反射面で多重反射しながら内部を通過して光軸ＡＸに垂直な平面にレーザ光源２０１の複数の虚像（見掛けの光源像）を形成する。従って内面反射型インテグレータ２０４の光射出面２０４′では、これら複数の虚像からあたかも射出したかのように見える複数の光束が互いに重ね合わされるので、光射出面２０４′における照度分布は均一になる。この現象については後で図２５を用いて説明する。

【００９１】内面反射型インテグレータ２０４に入射する時のレーザー光の発散角（出射角度保存光学素子２０２と集光光学系２０３に依存する）と、内面反射型インテグレータ２０４の長さと幅（径）とを考慮しつつ内面反射型インテグレータ２０４の形状を決定すると、各虚像から出て被照明物体２０９に入射する個々のレーザ光の光路長差がレーザ光固有のコヒーレンス長以上に設定でき、レーザー光の時間的コヒーレンスを低下させさせることにより被照明物体２０９上でのスペックルの発生を抑えることができる．さて図２２に戻り、内面反射型インテグレータ２０４の光出射面２０４′に形成された均一な照度分布（光強度分布）を持つ面光源（光）は、

光束調整手段１１を介しズーム光学系２０５により所望の倍率で、波面分割型インテグレータ２０７の光入射面２０７′上へ拡大結像され、光入射面２０７′上に均一光源像２０６が形成されることになる。

【００９２】光入射面２０７′上に均一光源像２０６が形成されると、光入射面２０７′の光強度分布がそのまま波面分割型インテグレータ２０７の光射出面２０７″に転写され、光射出面２０７″又はその近傍には、個々の強度が互いにほぼ等しい多数個の点光源より成る、光強度分布が均一な面光源が形成される。

【００９３】光射出面２０７″又はその近傍の多数個の点光源から射出する各光束は、絞り１２を介し集光光学系２０８により、被照明物体２０９上で互いに重なり合うように物体を照明するので、被照明物体２０９全体の照度分布は均一となる。

【００９４】上記の「所望の倍率」とは被照射物体２０９へ入射する照射光束の開き角（出射角度）αが露光に最適な値になるように均一光源像２０６の大きさが設定される倍率であり、被照明物体が微細パターンを有するマスク（レチクル）等の場合には、マスクパターンの種類（最小パターン線幅の大小）に応じてこの「所望の倍率」が変えられる。

【００９５】「所望の倍率」をｍとする時、内面反射型インテグレータ２０４から出射する光束の開き角（出射角度）βに依存するズーム光学系２０５の光入射側開口数をＮＡ′、波面分割型インテグレータ２０７に入射する光束の開き角（入射角度）θに依存するズーム光学系２０５の光出射側開口数をＮＡ″とすると、ＮＡ′＝ｍ・ＮＡ″　が成立する。ここで、角度θの大きさは波面分割型インテグレータ２０７の光入射側開口数ＮＡを越えない範囲で、且つこの開口数ＮＡにできるだけ近い値であることが、照明光の利用効率の観点から望ましい。

【００９６】従って本実施例の照明装置では、角度θの値は、倍率ｍの値の変化によらず、常時、波面分割型インテグレータ２０７の入射側開口数に適合した最適角度に設定されるようにしている。

【００９７】即ち、マスクの種類などの露光の条件が変わり、ズーム光学系２０５の最適な倍率ｍの値を無視できない程度に変える時には、内面反射型インテグレータ２０４からの出射する光束の開き角βの値も変えることにより、照明光の利用効率が低下しないようにする。尚、ある条件の露光に最適な倍率ｍが決まると、（１）式に基いて、内面反射型インテグレータ２０４から出射する光束の開き角β（射出角度β）の最適角度が適宜決める。

【００９８】本実施例の照明装置は、角度βの値が内面反射型インテグレータ２０４へ入射する光束の入射角度φに等しく且つ入射角度φが出射角度保存光学素子２０２からの光束の開き角（出射角度）εに依存していることを利用し、出射角度保存光学素子２０２を露光条件に応じて他の出射角度εが異なる出射角度保存光学素子に切り換えることにより、角度θの値を一定又はほぼ一定に維持している。

【００９９】この出射角度保存光学素子２０２の切り換えについて図２４（Ａ）及び（Ｂ）を用いて説明する。

【０１００】図２４において、２０２ａは出射角度ε（＝εａ）が小さい出射角度保存光学素子であり、２０２ｂは出射角度ε（＝εｂ）が大きい出射角度保存光学素子であり、その他の符番については図２２で説明した符番と同じ部材を指す。

【０１０１】一般に半導体チップ製造用投影露光装置の照明装置においては、被照明物体２０９であるマスク（レチクル）のパターン形成面に入射する光束の開き角（入射角度）αを最適角度に設定し且つ入射光束の利用効率（光量）も高く維持することが要求されるので、本実施例の照明装置では、ズーム光学系と複数個の出射度保存光学素子２０２を用意し、マスクの種類の変更等必要に応じて、ズーミングと光学素子の切り替えを行なうことにより達成している。

【０１０２】図２４（Ａ）はマスク２０９に入射する光束の入射角度αが比較的小さい場合（この状態を「小σ（シグマ）」の状態と言う。）を示し、マスク２０９の回路パターンの最小線幅が比較的大き場合（サブミクロンの範囲ではあるが）に対応する。尚、σ（シグマ）は照明光学系の光出射側開口数Ｎｉと投影光学系の光入射側開口数Ｎｐの比（Ｎｉ／Ｎｐ）を意味する。

【０１０３】この小σの状態を設定するためには、波面分割型インテグレータ２０７の光入射面２０７′上に内面反射型インテグレータ２０４の光出射面２０４′（そこ又はその近傍にある面光源）を小さい倍率で結像する必要がある。これはズーム光学系２０５の倍率を小さくすることにより達成されるが、前述したように入射角度θは波面分割型インテグレータ２０４の構成に依存した最適角度に維持される必要がある。そこで、この小σ値の状態に変える時には、入射角度αの値に対応する倍率になるようにズーム光学系の倍率を変えると共に、入射角度θの値が最適値に維持されるように、出射角度がεｂ（＞εａ　）である出射角度保存光学素子２０２ｂを出射角度がεａである出射角度保存光学素子２０２ａに切換える。

【０１０４】図２４（Ｂ）はマスク２０９に入射する光束の入射角度αが比較的大きい場合（この状態を「大σ（シグマ）」の状態と言う。）を示し、マスク２０９の回路パターンの最小線幅が比較的小さい場合（サブミクロンの範囲ではあるが）に対応する。この大σの状態を設定するためには、波面分割型インテグレータ２０７の光入射面２０７′に内面反射型インテグレータ２０４の光出射面２０４′（そこ又はその近傍にある面光源）を大きい倍率で結像する必要がある。これはズーム光学系２０５の倍率を大きく大きくすることにより達成される

が、前述したように入射角度θは波面分割型インテグレータ４の構成に依存した最適角度に維持される必要がある。そこで、この大σ値の状態に変える時には、入射角度αの値に対応する倍率になるようにズーム光学系の倍率を変えると共に、入射角度θの値が最適値に維持されるように、出射角度がεa（＜εb）である出射角度保存光学素子２０２ａを出射角度がεbである出射角度保存光学素子２０２ｂに切換える。

【０１０５】ここでは、ズーム光学系の結像倍率と出射角度保存光学素子とを２段階で切換える説明を行なったが、ズーム光学系の結像倍率と出射角度保存光学素子とを3段階以上で切換えるように構成することもできる。上記実施例のズーム光学系は所定の範囲で連続的に倍率を変えられるから３段階以上の倍率変更は容易で、従ってそのまま使用でき、又、出射角度保存光学素子は、互いに焦点距離が異なる３種類以上の出射角度保存光学素子を準備しておけばいい。尚、出射角度保存光学素子を切換えてもそれらによるレーザー光の集光位置（本実施例の場合無限遠にある発光部の実像又は虚像の絶対位置）は略一定に維持される構成とする。

【０１０６】又、ズーム光学系として互いに結像倍率が異なる複数種の結像光学系を用意しておき、２つのインテグレータ２０４、２０７の間に選択的に一つの結像光学系を設けるようにしてもいい。一方、出射角度保存光学素子に、光軸方向に動く複数のレンズを有するズーム光学系を用いてもいい。

【０１０７】次に内面反射型インテグレータ２０４の光射出面２０４′の照度分布が均一になる理由について図２５を用いて説明する。

【０１０８】図２５では、内面反射型インテグレータ２０４は六角柱状のガラス棒であるとする。尚、図２５は光軸ＡＸを含む側断面図である。

【０１０９】不図示の集光光学系２０３からのレーザー光は焦点Ｐ０に一旦集光（結像）し、その後、発散角ϕを有する発散光束となる。この時、レーザー光がエキシマレーザ光である場合は、一般に大強度であるため、焦点Ｐ０近傍では莫大なエネルギー密度となり、内面反射型インテグレータ２０４の光入射面のコーティング（反射防止膜）や硝材そのものを破壊してしまう恐れがある。従って、このような場合は図示の通り焦点Ｐ０から少し距離をおいて内面反射型インテグレータ２０４を配置する。

【０１１０】内面反射型インテグレータ２０４に入射した発散光束は内面反射面で繰り返し反射（所謂全反射）しながら内部を通過した後、入射した際の発散角度２０４Ｉを保ったまま内面反射型インテグレータ２０４から出射する。この時、内面反射型インテグレータ２０４の内面反射面の各部分において反射された光束は反射後も発散しているので、各部分において反射された光束は、破線により示されているように、後方に虚像Ｐ１、Ｐ２、Ｐ３、Ｐ４、Ｐ５、Ｐ６、Ｐ７、Ｐ８、Ｐ９、Ｐ１０を形成する。図示してはいないが、実際には六角柱のガラス棒の場合には、残りの二組の内面反射面対の作用により上記と同様な虚像群が更に形成されている。

【０１１１】従って内面反射型インテグレータ２０４の光射出面２０４′では、これら多数の虚像からあたかも射出したかのように見える多数の光束が互いに重なり合い、照度分布が均一になる。

【０１１２】図２６は図２５の内面反射型インテグレータ２０４により生じた虚像（見掛けの光源像）群の配列を、例えば図２４（Ａ）の配置において波面分割型インテグレータ２０７を構成する一つの微小レンズの光射出面から見た図を示している。図２６において、２５１は波面分割型インテグレータ２０７の微小レンズを、Ｐ１からＰ１０は図２５の虚像を示している。図２６から分かる通り、内面反射型インテグレータ２０４が六角柱の光パイプの場合には虚像群は蜂の巣状に配列するが、内面反射型インテグレータ２０４が四角柱の光パイプである場合は虚像群は矩形の格子状に配列する。尚、この虚像は、集光光学系２０３と内面反射型インテグレータ２０４の間に形成されたレーザー光の集光点（点光源）の像である。

【０１１３】本実施例の照明装置は、図２４（Ａ）に示した通り出射角度保存光学素子２０２ａ、２０２ｂが$m \times n$個の微小レンズより成るハエの目レンズ（$m \geqq 2$、$n \geqq 2$）であるから、虚像群の一つ一つの虚像は$m \times n$程度に分割された複数像で構成される。従ってこの分割複数像が蜂の巣状に並んだ虚像が見え、これらが波面分割型インテグレータ２０７の微小レンズ一つに対応することになる。

【０１１４】従って、本実施例の照明装置は、波面分割型インテグレータ２０７の光出射面２０７″又はその近傍に形成された複数の点光源（有効光源）からの各光束を集光光学系２０８により被照明物体２０９上に重畳して照明する際の点光源（有効光源）の数を非常に多くしており、被照明物体２０９全体がより均一な照度分布となるように物体２０９を照明することを可能にしている。

【０１１５】また、図２３（Ｂ）で説明したように、レーザ光源２０１からの光束が外乱により微小変位したとしても、出射角度保存光学素子２０２ａ、２０２ｂからの光束の出射度εは一定に維持されるので、図２６における分割複数像の各々が微小変動するだけであって、蜂の巣状を成す虚像群には変動がなく、出射角度保存光学素子２０２ａ、２０２ｂ波面分割型インテグレータ２０７の各微小レンズ２５１の中の虚像全体をマクロに見たときの変動は殆どなく、従って被照明物体２０９上の照度分布への影響も無視できる程度に小さくなる。

【０１１６】従って本実施例の照明装置は、レーザ光源２０１からのレーザー光が変位しても非常に性能が安定

している系である。尚、光束調整手段１１及び絞り１２の光学的作用は前述の各実施形態と同様である。

【０１１７】図２７に上記実施例の照明装置をＬＳＩやＶＬＳＩ等の半導体チップや、ＣＣＤ、磁気センサ、液晶素子等のデバイスを製造するステップ＆リピート型又はステップ＆スキャン型投影露光装置に適用した実施形態２を示す。

【０１１８】図２７において、２９１はＡｒＦエキシマレーザやＫｒＦエキシマレーザレーザ等のレーザー光源２０１からの平行光束を所望のビーム形状に整形するための光束整形光学系、２９２はコヒーレントなレーザ光束をインコヒーレント化するためのインコヒーレント化光学系、、２９３はマスク２０９の回路パターンの等倍像又は縮小像を投影する投影光学系、２９４は基板（シリコンやガラス）に感光材を塗布したウエハを示す。又、ここでは図２２に示した部材と同じ部材には図２２と同じ符番を付し、説明は省略する。

【０１１９】レーザー光源２０１からのレーザー光は、投影光学系２９３が色収差補正されていない場合にはスペクトル線の半値幅が１ｐｍ－３ｐｍ程度に狭帯域化されており、投影光学系２９３が色収差補正されている場合には、スペクトル線の半値幅が１０ｐｍ以上のある値に狭帯域化されている。又、投影光学系２９３が色収差補正されている場合に狭帯域化されていないレーザー光を用いる場合もある。

【０１２０】投影光学系２９３としては複数のレンズ素子のみで構成した光学系や複数のレンズ素子と少なくとも一枚の凹面鏡とで構成した光学系や複数のレンズ素子と少なくとも一枚のキノフォーム等の回折光学素子とで構成した光学系が使用できる。色収差の補正は、互いに分散値（アッベ数）の異なる硝材より成る複数のレンズ素子を用いたり、上記回折光学素子をレンズ素子と逆方向の分散が生じるように構成したりする。

【０１２１】レーザ光源２０１から射出したレーザ光は不図示のミラーやリレーレンズから成る光束引き回し光学系を経て光束整形光学系２９１に入射する。この光束整形光学系２９１は、複数のシリンドリカルレンズやビームエクスパンダ等より構成されており、レーザー光の（光軸ＡＸと垂直な）断面形状の寸法の縦横比率を所望の値に変換する。

【０１２２】光束整形光学系２９１により断面形状が整形された光束は、ウエハ２９４上で光が干渉してスペックルを生じることを防ぐ目的でインコヒーレント化光学系２９２に入射し、光学系２９２によりスペックルが生じにくいインコヒーレントな光束に変換される。

【０１２３】インコヒーレント化光学系２９２としては、例えば特開平3-215930号公報の図１に開示されているような、入射光束を光分割面で少なくとも２つの光束（例えばｐ偏光とｓ偏光）に分岐した後で一方の光束を光学部材を介して他方の光束に対してレーザー光のコヒーレンス長以上の光路長差を与えてから該分割面に再導光して他方の光束と重ね合わせて射出されるようにした折り返し系を少なくとも一つ備える光学系を用いることができる。

【０１２４】インコヒーレント化光学系２９２からのインコヒーレント化された光束は、出射角度保存光学素子２０２に入射する。以下図２２乃至図２６を用いて述べた手順により、波面分割型インテグレータ２０７の各微小領域（微小レンズ）から出射した光束が集光光学系２０８によりマスク２０９を重畳して照明し、マスク２０９の投影すべき回路パターン全面で均一な照度分布が得られるようにマスク２０９を均一照明する。そしてマスク２０９上に形成された回路パターンが投影光学系２９３によりウエハ２９４上に投影結像され、ウエハ２０４の感光材料への回路パターン（像）の露光が行なわれる。尚、ウエハ２９４は不図示のＸＹＺ可動ステージに真空吸着法等により固定されており、ＸＹＺ可動ステージは紙面の上下左右前後に平行移動する機能を持ち、その移動は不図示のレーザ干渉計等の測長器で制御される。このような技術は周知技術であるので、詳しい説明は省略する。

【０１２５】図２７においては、波面分割型インテグレータ２０７の光出射側光路中に照明用の開口絞り１２が配置されており、絞り１２は互いに異なるσ値に対応する複数の開口絞りを円盤（ターレット）等に設けており、ズーム光学系のズーミングと出射角度保存光学素子の切換えに連動させて円盤を回転させることにより、σ値に合わせて所望の開口絞りを波面分割型インテグレータ２０７の光出射側光路中に挿入するように構成している。

【０１２６】複数の開口絞りの開口形状としては、通常の円形開口や円環（リング）状開口や特開平4-329623号公報（鈴木）に記載された光軸外の４つの開口等が使える。

【０１２７】図２８及び図２９を用いて本発明の照明装置の実施形態５を説明する。

【０１２８】図２８及び図２９は、ＬＳＩやＶＬＳＩ等の半導体チップや、ＣＣＤ、磁気センサ、液晶素子等のデバイスを製造するステップ＆スキャン（走査）型の投影露光装置に好適な照明装置の概略図である。図２８、図２９において前述した各実施形態と異なる部分のみを説明する。

【０１２９】図２８（Ａ）と（Ｂ）は本実施例の照明装置が前述の小σの状態にある場合を示しており、（Ａ）は照明装置をスキャン方向（以下、「ｚ方向」と記す。）から見た図で、（Ｂ）は照明装置をスキャン方向と直交する方向（以下、「ｙ方向」と記す。）から見た図である。又、図２９（Ａ）と（Ｂ）は本実施例の照明装置が前述の大σの状態にある場合を示しており、（Ａ）は照明装置をｚ方向から見た図で、（Ｂ）は照明

装置をｙ方向から見た図である。

【０１３０】尚、以下、図２９（Ａ）、（Ｂ）において光軸ＡＸと光軸ＡＣからｙ方向に延びる軸とを含む断面をｘｙ断面、光軸ＡＸからｚ方向に延びる軸とを含む断面をｘｚ断面と記す。図２８及び図２９において、２２０ａ、２２０ｂはＸＹ断面とＸＺ断面とで出射光束の開き角（出射角度）が異なる出射角度保存光学素子、２４０は内面反射型インテグレータ、２４０′は内面反射型インテグレータの光出射面、２７０は波面分割型インテグレータ、２７０′、２７０″は波面分割型インテグレータの光入射面、光出射面、３００ｙはマスク上の照明域（光）のｙ方向の長さ、３００ｚはマスク上の照明域（光）のｚ方向の長さを示す。又、図中の図２２乃至図２７で示した部材と同じ部材には図２４と同一の符番を付している。

【０１３１】図２８及び図２９で示す本実施例の照明装置の基本的な構成と機能は、その変形例も含めて図２２乃至図２７で示した前記実施例の照明装置と同じであり、本実施例の照明装置の前記実施例の照明装置との相違点は出射角度保存光学素子と内面反射型インテグレータと波面分割型インテグレータの構成と機能にある。従って、ここでは前記実施例との相違点のみ説明することにする。

【０１３２】ステップ＆スキャン型の投影露光装置では、ｙ方向に延びた（ｚ方向よりもｙ方向の方が長い）矩形スリット状の照明域をマスク２０９上に効果的に形成する必要がある。

【０１３３】そこで本実施例では、出射角度保存光学素子として、光軸ＡＸと光軸ＡＸからｙ方向に延びる軸とを含む断面（以下、「ｘｙ断面」と記す。）に関する焦点距離と光軸ＡＸと光軸ＡＸからｚ方向に延びる軸とを含む断面（以下、「ｘｚ断面」と記す。）に関する焦点距離とが互いに異なるアナモフィック光学系より成る素子２２０ａと２２０ｂを用い、内面反射型インテグレータとして、光軸と直交する断面（以下、「ｙｚ断面」と記す。）の形状がｙ方向に延びる一対の直線とｚ方向に延びる一対の直線とで表わされる四角柱の光パイプより成るインテグレータ２４０を用い、波面分割型インテグレータとして、個々の微小レンズのｙｚ断面の形状がｙ方向に延びる矩形であるフライアイレンズより成るインテグレータ２７０を用いている。

【０１３４】出射角度保存光学素子２２０ａと２２０ｂは、各々ｘｙ断面における焦点距離がｘｚ断面における焦点距離よりも小さく、従って、各断面で見た光束の開き角（出射角度）の関係は、ｙｚ断面における出射角度εａｙ、εｂｙの方がｘｚ断面における出射角度εａｚ、εｂｚよりも大きい。従って、図示された光束の開き角（出射角度又は入射角度）φｙ、φｚ、βｙ、βｚ、θｙ、θｚ、γｙ、γｚ、αｙ、αｚの関係も、φｙ>φｚ、βｙ>βｚ、θｙ>θｚ、γｙ>γｚ、αｙ>αｚである。ここで、γｙ>γｚであるので、マスク９上ではｙ方向に延びた矩形スリット状の照明域が形成される。

【０１３５】又、前記実施例と同様に、σの大小に依存してεａｙ<εｂｙ、εａｚ<εｂｚの関係があり、角柱状の光パイプの性質に依存してφｙ＝βｙ、φｚ＝βｚの関係がある。

【０１３６】出射角度保存光学素子２２０ａと２２０ｂは、ｘｙ断面とｘｚ断面とで焦点距離が異なる微小レンズを複数個２次元的にｙｚ断面にそって並べたフライアイレンズや図２３（Ａ）の絞り２２１としてｙ方向に延びたスリット開口を有するものを用いた素子も適用可能である。尚、各フライアイレンズを構成する微小レンズは、通常のレンズや回折光学素子（フレネルレンズ）によって構成される。

【０１３７】図３０は図２８及び図２９の内面反射型インテグレータ２４０により生じた虚像（見掛けの光源像）群の配列を、波面分割型インテグレータ２７０を構成する一つの微小レンズの光射出面から見た図を示している。図３０において、３２０は波面分割型インテグレータ２７０の微小レンズを、Ｙ１からＹ１２及びＺ１からＺ８は虚像を示している。

【０１３８】図３０から分かると通り、内面反射型インテグレータ２４０が四角柱の光パイプであるので、虚像群はｙ方向とｚ方向と沿って格子状に配列する。又、内面反射型インテグレータ２４０に入射する発散光束の入射角度がｘｙ断面とｘｚ断面とで互いに異なるので、内面反射面での反射回数がｘｙ断面とｘｚ断面とで互いに異なり、そのためｙ方向とｚ方向とで虚像の数が異なっている。尚、この虚像は、集光光学系２０３と内面反射型インテグレータ２４０の間に形成されたレーザー光の集光点（点光源）の像である。

【０１３９】本実施例の照明装置は、図２８及び図２９に示した通り出射角度保存光学素子２２０ａ、２２０ｂがｍ×ｎ個の微小レンズより成るハエの目レンズ（ｍ≧２、ｎ≧２）であるから、虚像群の一つ一つの虚像はｍ×ｎ程度に分割された複数像で構成される。従ってこの分割複数像が格子状に並んだ虚像が見え、これらが波面分割型インテグレータ２７０の微小レンズ一つに対応することになる。

【０１４０】従って、本実施例の照明装置も、波面分割型インテグレータ２７０の光出射面２０７″又はその近傍に形成された複数の点光源（有効光源）からの各光束を集光光学系２０８によりマスク２０９上に重畳して照明する際の点光源（有効光源）の数を非常に多くしており、マスク２０９全体がより均一な照度分布となるようにマスク２０９を照明することを可能にしている。

【０１４１】以上のような構成を有する本実施例の照明装置も、前記実施例同様に、マスク２０９の種類等に応じて小σの状態と大σの状態を作る際に、ズーム光学系

２０５の結像倍率を小さな値と大きな値の間で切換え且つ出射角度保存光学素子２２０ａと出射角度保存光学素子２２０ｂを切換えることにより、角度θｙ、θｚの各々の値を一定又はほぼ一定に維持しつつ角度αｙ、αｚの各々の値を変えることができ、光の利用効率を低下させることなくσを変更することが可能である。又、レーザー光源からのレーザー光が変位してもマスク２０９上で照度むらが生じることもない。

【０１４２】図３１に図２８乃至図３０で示した照明装置をＬＳＩやＶＬＳＩ等の半導体チップや、ＣＣＤ，磁気センサ、液晶素子等のデバイスを製造するステップ＆スキャン型等の走査型露光装置に適用した実施形態３を示す。

【０１４３】図３１において、２９１はＡｒＦエキシマレーザやＫｒＦエキシマレーザ等のレーザ光源２０１からの光束を所望のビーム形状に整形するための光束整形光学系、２９２はコヒーレントなレーザ光束をインコヒーレント化するためのインコヒーレント化光学系、２９３はマスク２０９の回路パターンの等倍像又は縮小像を投影する投影光学系、２９４は基板（シリコンやガラス）に感光材を塗布したウエハを示す。又、ここでは図２８乃至図３０に示した部材と同じ部材には図２８乃至図３０と同じ符番を付し、説明は省略する。

【０１４４】レーザ光源２０１から射出したレーザ光は不図示のミラーやリレーレンズから成る光束引き回し光学系を経て光束整形光学系２９１に入射する。この光束整形光学系２９１は、複数のシリンドリカルレンズやビームエクスパンダ等より構成されており、レーザー光の（光軸ＡＸと垂直な）断面形状の寸法の縦横比率を所望の値に変換する。

【０１４５】光束整形光学系２９１により断面形状が整形された光束は、ウエハ２９４上で光が干渉してスペックルを生じることを防ぐ目的でインコヒーレント化光学系２９２に入射し、光学系２９２によりスペックルが生じにくいインコヒーレントな光束に変換される。

【０１４６】インコヒーレント化光学系２９２としては、特開平3-215930号公報の図１に開示されているような、前述の光学系を用いることができる。

【０１４７】インコヒーレント化光学系２９２からのインコヒーレント化された光束は、出射角度保存光学素子２２０ａ又は２２０ｂに入射する。以下最初の実施例で図２３乃至図２６を用いて述べた手順と同様の手順により、波面分割型インテグレータ２７０の各微小領域（微小レンズ）から出射した光束が集光光学系２０８によりマスク２０９を重畳して照明し、マスク２０９の投影すべき回路パターン全面で均一な照度分布が得られるようにマスク２０９を均一照明する。この時、マスク２０９上には、ｙ方向に伸びる矩形スリット状の照明域（光）が形成される。そしてマスク２０９上に形成された回路パターンの内の前記照明域が形成された部分が投影光学系２９３によりウエハ２９４上に投影結像され、ウエハ２９４の感光材料への回路パターン（像）の露光が行なわれる。

【０１４８】ウエハ２９４は不図示のｘｙｘの各方向に移動可能なＸＹＺ可動ステージに真空吸着法等により固定されており、マスク２０９も不図示のｘｙｘの各方向に移動可能なＸＹＺ可動ステージに真空吸着法等により固定されており、各ＸＹＺ可動ステージの移動は不図示のレーザ干渉計等の測長器で制御される。そして、マスク２０９の回路パターン部の端部に矩形スリット状の照明域を形成した状態で各ＸＹＺ可動ステージを移動させて、マスク２０９をｚ方向にウエハ２９４を－ｚ方向に走査することにより、マスク２０９の回路パターン全体をウエハ２９４上に投影して回路パターン全体をウエハ２９４上に転写する。尚、投影光学系２９３の投影倍率がＭ、マスク２０９の走査速度がＶの時、ウエハ２９４の走査速度は－Ｍ×Ｖである。

【０１４９】図３２は本発明のデバイス（ＩＣやＬＳＩ等の半導体チップ、或は液晶パネルやＣＣＤ等）の製造方法のフローチャートである。これについて説明する。

【０１５０】ステップ１（回路設計）では半導体デバイスの回路設計を行なう。

【０１５１】ステップ２（マスク製作）では設計した回路パターンを形成したマスクを製作する。一方、ステップ３（ウエハ製造）ではシリコン等の材料を用いてウエハを製造する。

【０１５２】ステップ４（ウエハプロセス）は前工程と呼ばれ、本発明の露光装置を用い、前記の用意した回路パターン（第１物体）を形成したマスク（レチクル）とウエハ（第２物体）を用いてリソグラフィ技術によってウエハ上に実際の回路を形成する。

【０１５３】ステップ５（組立）は後工程と呼ばれ、ステップ４によって作製されたウエハを用いて半導体チップ化する工程であり、アッセンブリ工程（ダイシング、ボンディング）、パッケージング工程（チップ封入）等の工程を含む。

【０１５４】ステップ６（検査）ではステップ５で作製された半導体デバイスの動作確認テスト、耐久性テスト等の検査を行なう。こうした工程を経て半導体デバイスが完成し、これが出荷（ステップ７）される。

【０１５５】図３３は上記のウエハプロセスのフローチャートである。

【０１５６】ステップ１１（酸化）ではウエハの表面を酸化させる。

【０１５７】ステップ１２（ＣＶＤ）ではウエハ表面に絶縁膜を形成する。

【０１５８】ステップ１３（電極形成）ではウエハ上に電極を蒸着によって形成する。

【０１５９】ステップ１４（イオン打込み）ではウエハにイオンを打ち込む。

【0160】ステップ15（レジスト処理）ではウエハに感光剤を塗布する。

【0161】ステップ16（露光）では本発明の露光装置によってレチクルの回路パターンをウエハに焼付露光する。

【0162】ステップ17（現像）では露光したウエハを現像する。

【0163】ステップ18（エッチング）では現像したレジスト以外の部分を削り取る。

【0164】ステップ19（レジスト剥離）ではエッチングがすんで不要となったレジストを取り除く。

【0165】これらのステップを繰り返し行なうことによってウエハ上に多重に回路パターンが形成される。

【0166】本実施形態の製造方法を用いれば、従来よりも短時間で半導体デバイスを製造することができる。

【0167】

【発明の効果】本発明によれば、以上のように各要素を設定することにより、通常照明法と変形照明法の切り替えが容易で、かつ高い照明効率で被照射面を均一に照明することができ、高集積度のデバイスを容易に製造することができる照明装置及びそれを用いた投影露光装置、デバイスの製造方法を達成することができる。

【0168】特に本発明によれば、通常照明と変形照明の切り替えを、光束混合手段の直後に様々な構成の光束調整手段を出し入れすることで容易に実現することができ、また照明光束を高い効率で利用することができる等の効果が得られる。

【図面の簡単な説明】

【図1】　本発明の照明装置の実施形態1の要部概略図

【図2】　本発明の照明装置を用いた投影露光装置の実施形態1の要部概略図

【図3】　本発明に係る光束調整手段の概略図

【図4】　本発明に係る絞り調整手段の概略図

【図5】　本発明に係るハエの目の入射面での照度分布の概略図

【図6】　本発明に係るハエの目の入射面での照度分布の概略図

【図7】　本発明に係る絞りで不要光を遮光した場合の有効光源を表す説明図

【図8】　本発明に係る光束調整手段を交換した場合の概略図

【図9】　本発明に係るハエの目入射面での照度分布の概略図

【図10】　本発明に係るハエの目入射面での照度分布の概略図

【図11】　本発明に係る絞りで不要光を遮光した場合の有効光源を表す説明図

【図12】　本発明に係る4重極照明の場合のハエの目入射面での照度分布の概略図

【図13】　本発明に係る絞りで不要光を遮光した場合の有効光源を表す説明図

【図14】　本発明に係る有効光源分布の説明図

【図15】　本発明の照明装置の実施形態2の一部分の要部概略図

【図16】　本発明に係る光束調整手段の概略図

【図17】　本発明に係る光束調整手段としての回折光学素子の位相分布の説明図

【図18】　本発明に係る光束調整手段としての回折光学素子の位相分布の説明図

【図19】　本発明に係る光束調整手段としての回折光学素子の位相分布の説明図

【図20】　本発明の照明装置の実施形態3の一部分の要部概略図

【図21】　本発明に係る光束調整手段の概略図

【図22】　本発明の照明装置の実施形態4を示す概略図

【図23】　出射角度保存光学素子の2つの例を示す概略図

【図24】　出射角度保存光学素子の切り換えについての説明図

【図25】　内面反射型インテグレータの機能についての説明図

【図26】　図22乃至図25の内面反射型インテグレータ204により形成される虚像群を示す説明図

【図27】　本発明の露光装置の実施形態2を示す概略図で、図22の照明装置を搭載した露光装置

【図28】　本発明の照明装置の実施形態5を示す概略図で、小σの状態における装置構成図

【図29】　本発明の照明装置の実施形態5を示す概略図で、大σの状態における装置構成図

【図30】　図28及び図29の内面反射型インテグレータ240により形成される虚像群を示す説明図

【図31】本発明の露光装置の実施形態3を示す概略図で、図28及び図29が示す照明装置を搭載した露光装置図

【図32】　本発明のデバイスの製造方法のフローチャート

【図33】　本発明のデバイスの製造方法のフローチャート

【図34】　従来の照明装置の要部概略図

【図35】　図24の一部分の説明図

【図36】　図24の一部分の説明図

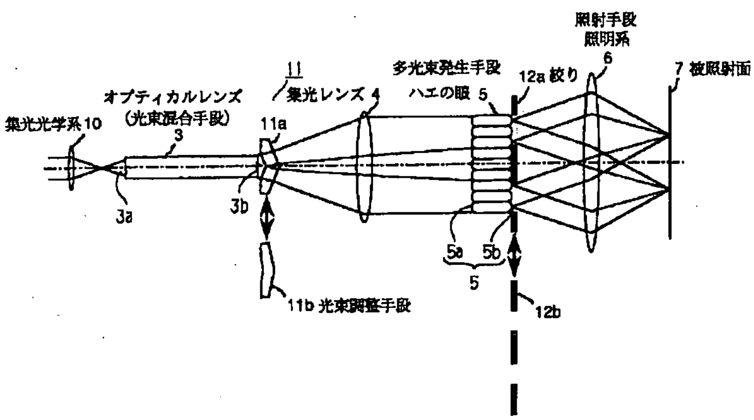
【図37】　図24の一部分の説明図

【符号の説明】

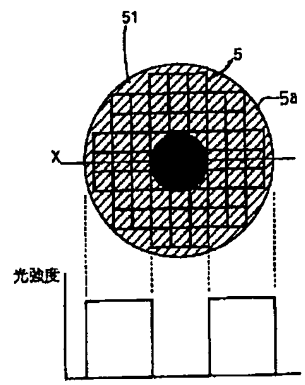
1　水銀灯（光源）
2　楕円ミラー
3　光束混合手段
4　集光レンズ
5　多光束発生手段
6　照射手段

7　被照射面（レチクル）
10　集光光学系
11　光束調整手段
12　絞り
24　投影レンズ
25　感光基板
201　レーザ光源
202　射出角度保存光学素子
203　集光光学系
204　内面反射型インテグレータ
205　ズーム光学系
207　波面分割型インテグレータ
208　集光光学系
209　マスク
293　投影光学系
294　ウエハ

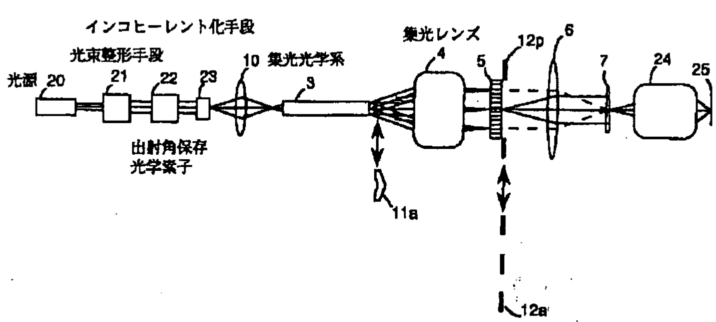
【図1】



【図5】



【図2】



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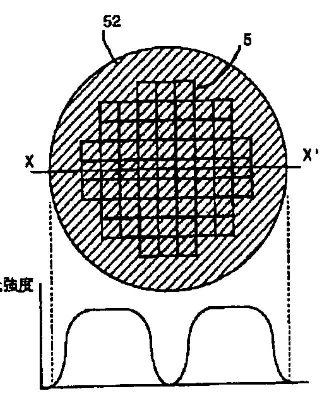
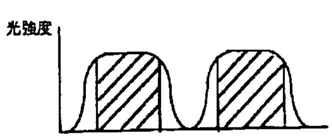
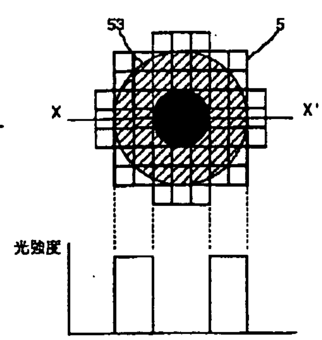


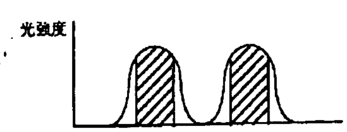
【図7】



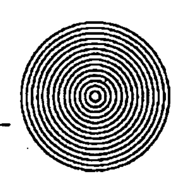
【図9】



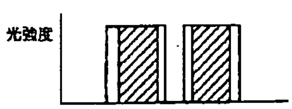
【図11】



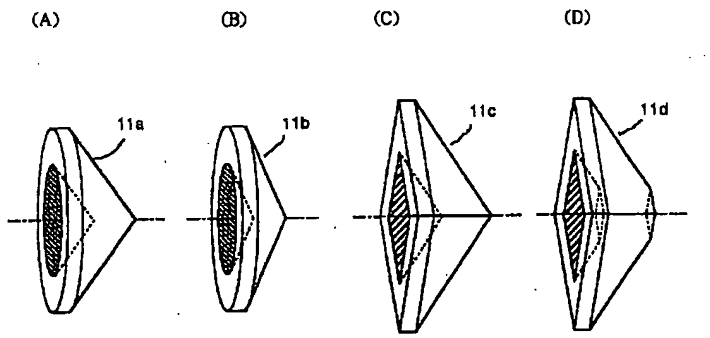
【図17】



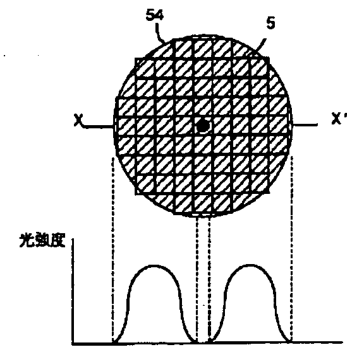
【図14】



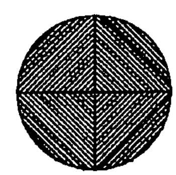
【図3】



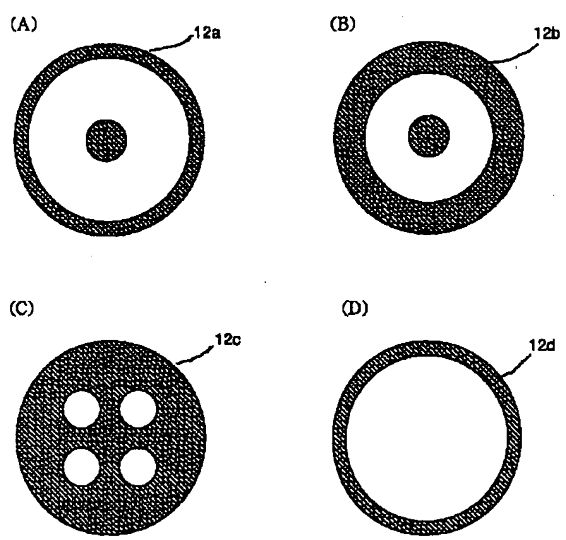
【図10】



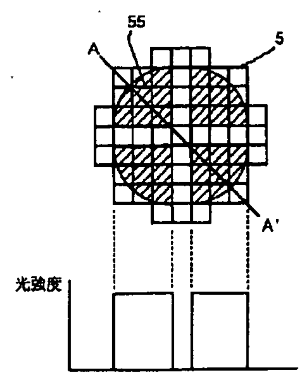
【図18】



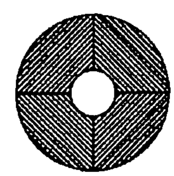
【図4】



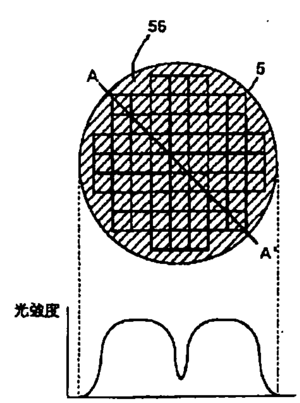
【図12】



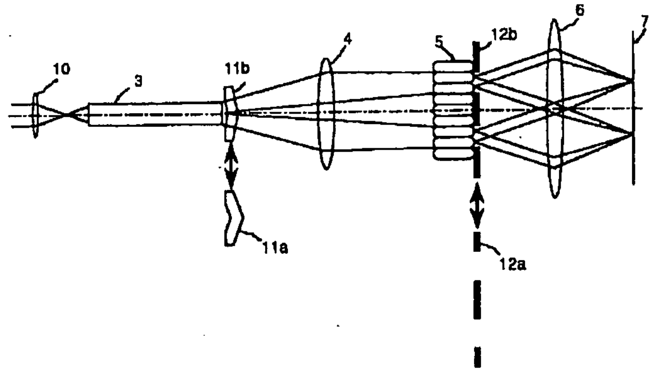
【図19】



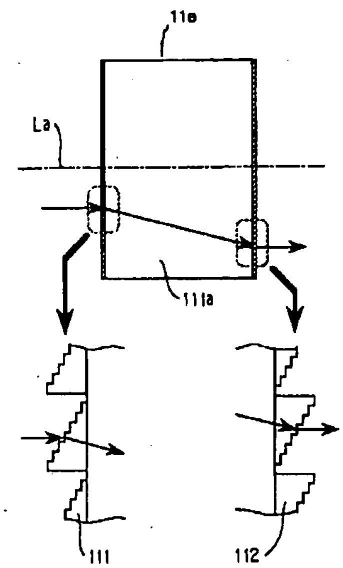
【図13】



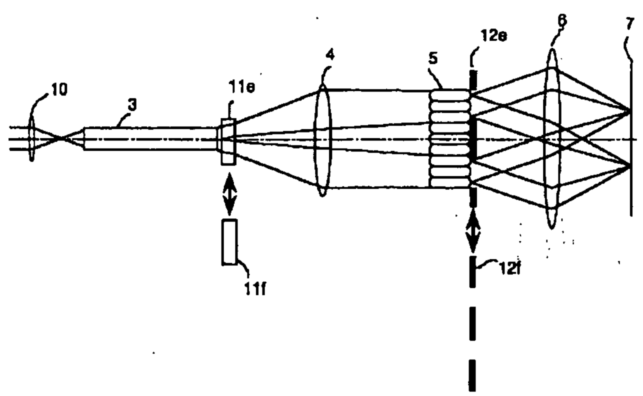
【図8】



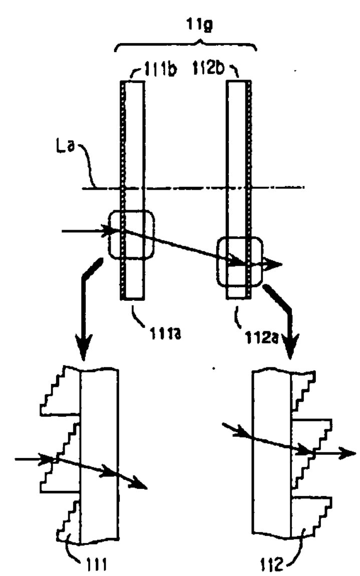
【図16】



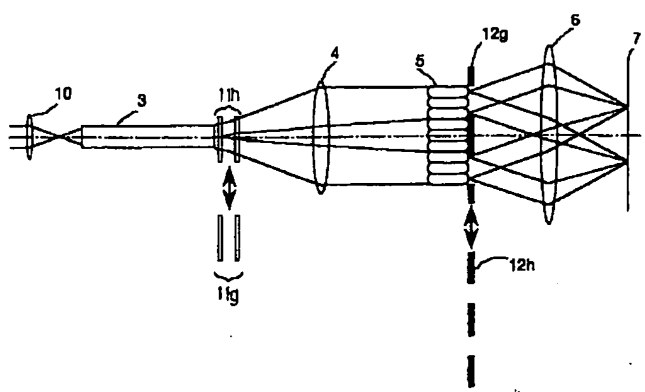
【図15】



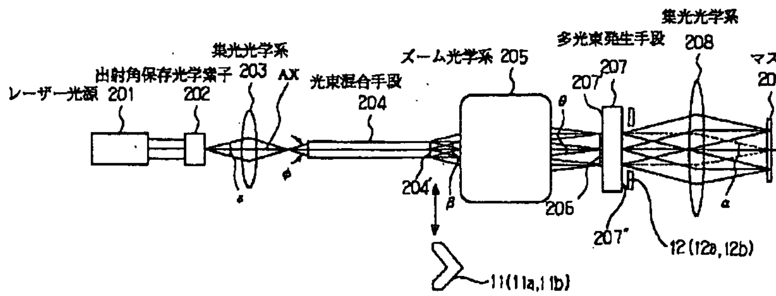
【図21】



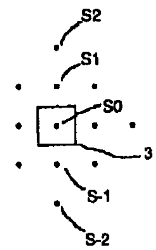
【図20】



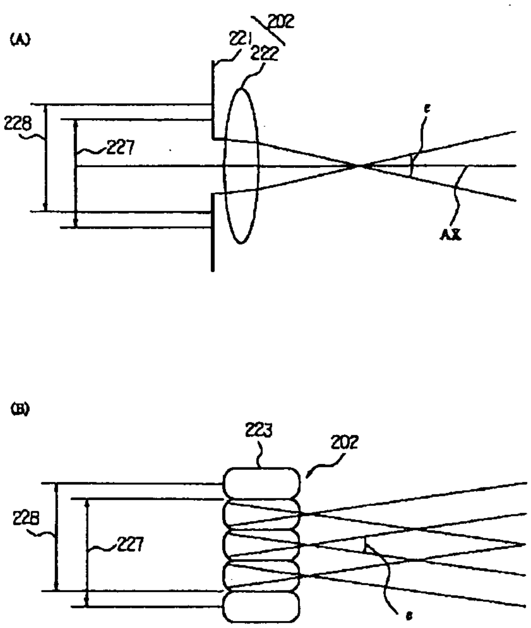
【図22】



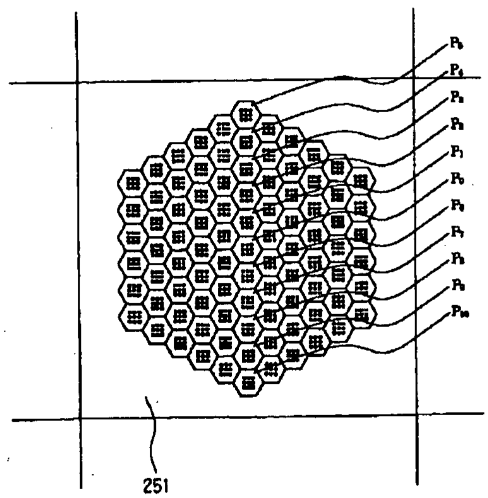
【図36】



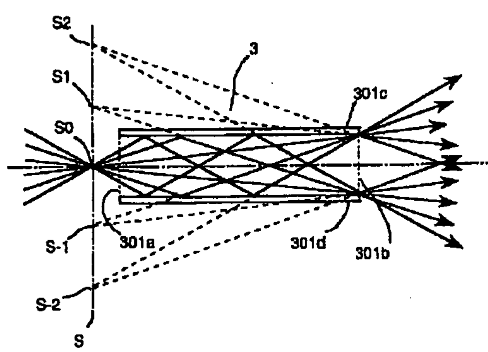
【図23】



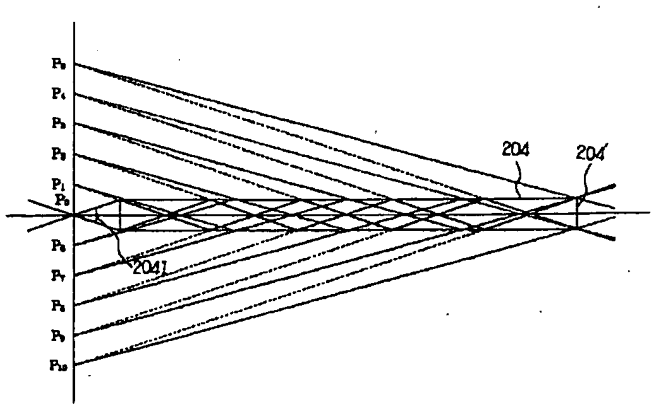
【図26】



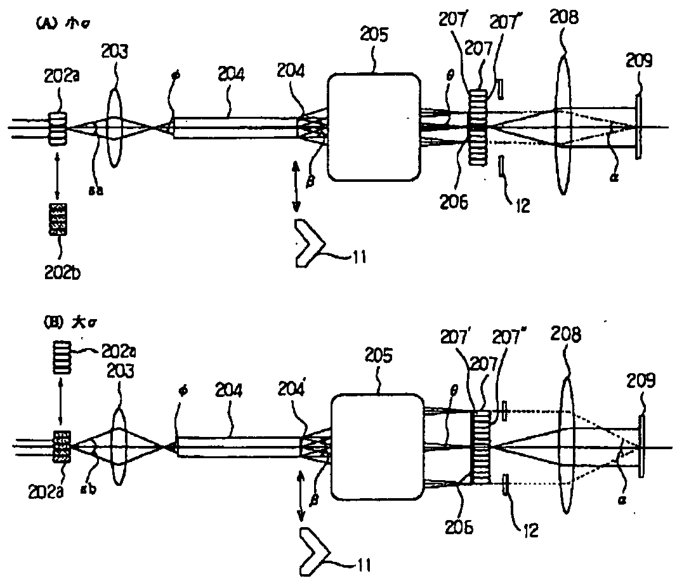
【図35】



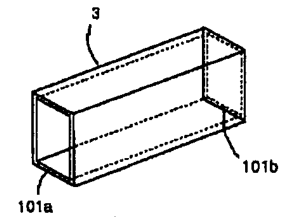
【図25】



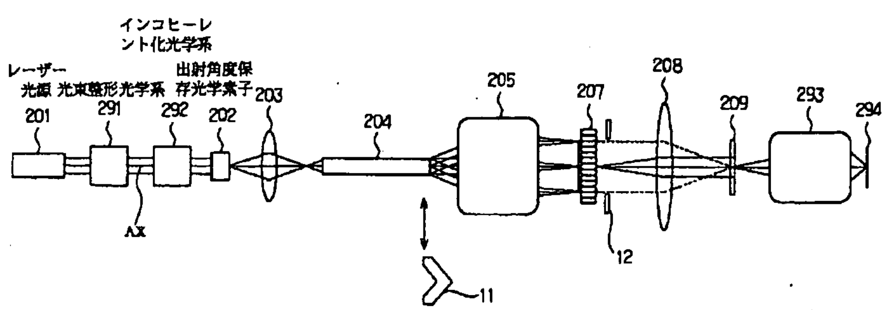
【図２４】



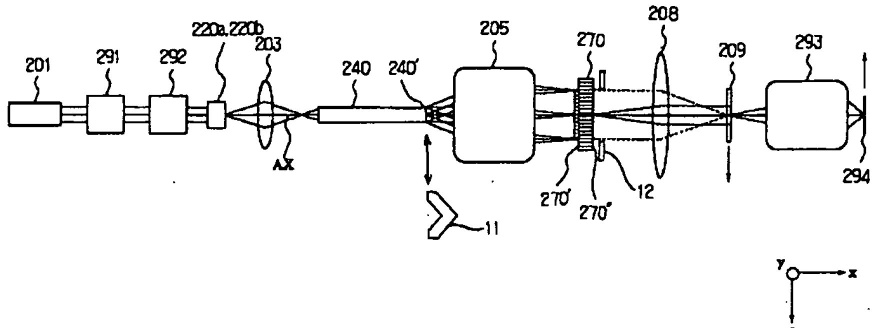
【図３７】



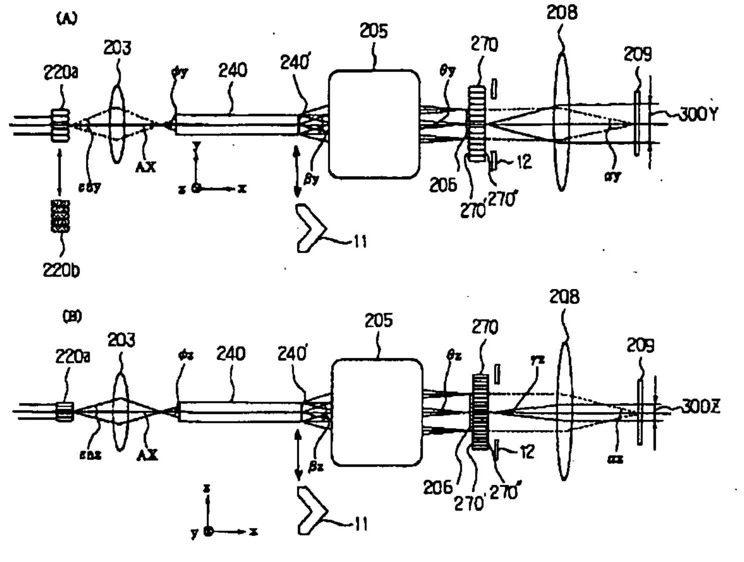
【図２７】



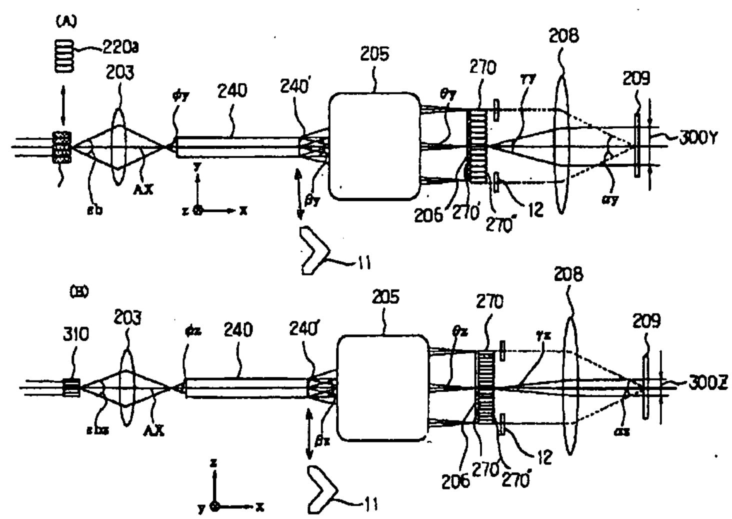
【図３１】



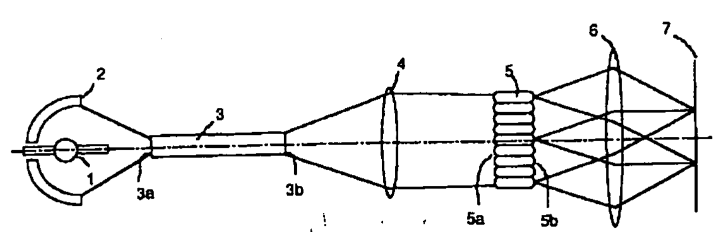
【図28】


(A)
220a
203
205
208
209
240
240'
270
300Y
12
206
270'
270"
AX
11
220b
(B)
300Z

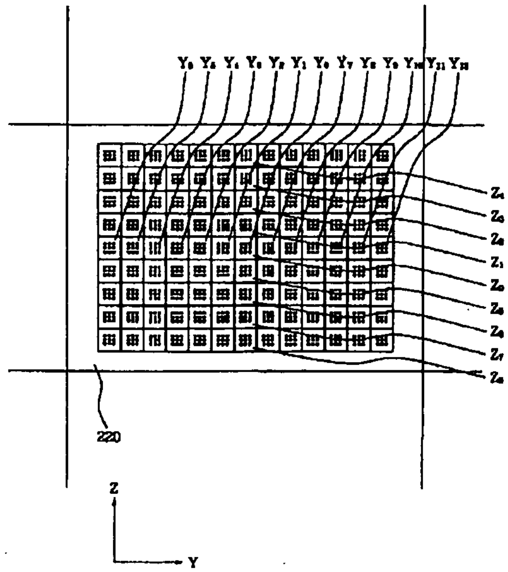
【図29】


(A)
220a
203
240
240'
205
270
208
209
300Y
AX
206
270'
270"
12
11
(B)
310
300Z

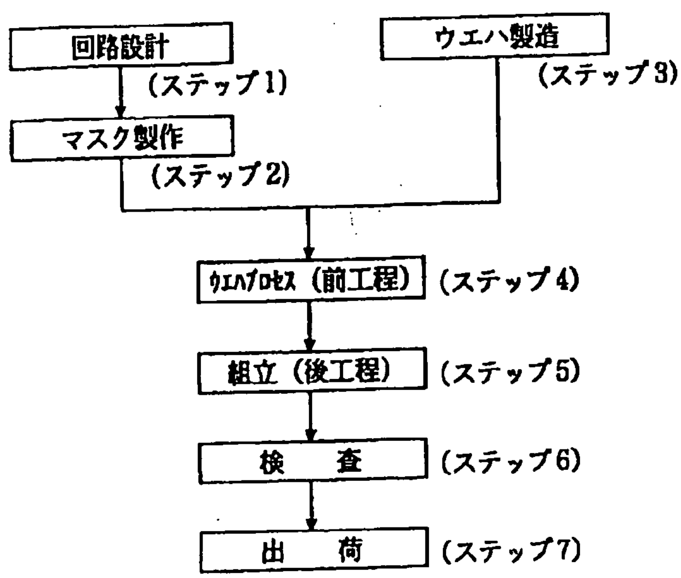
【図34】


1
2
3
3a
3b
4
5
5a
5b
6
7

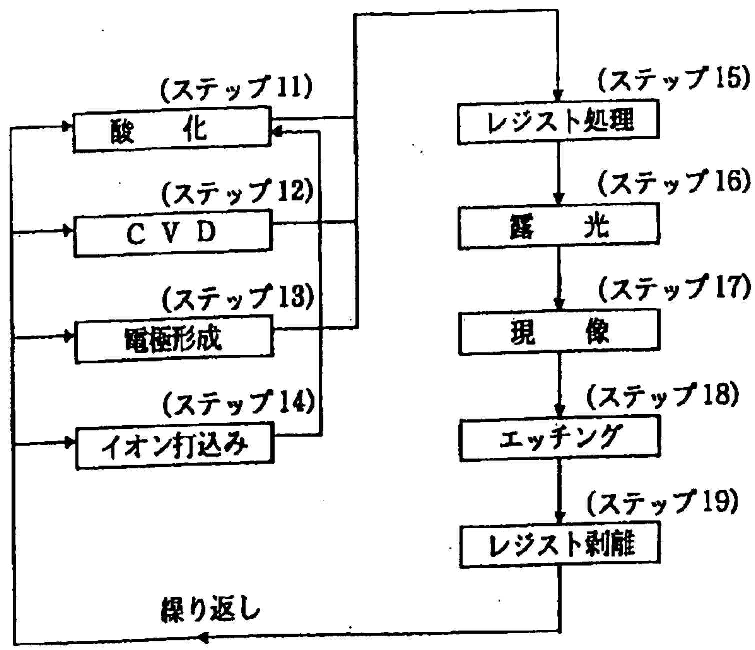
【図30】


220
Z
Y

【図32】


回路設計
(ステップ1)
マスク製作
(ステップ2)
ウエハ製造
(ステップ3)
ウエハプロセス（前工程）
(ステップ4)
組立（後工程）
(ステップ5)
検　査
(ステップ6)
出　荷
(ステップ7)

【図33】


(ステップ11)
酸　化
(ステップ12)
ＣＶＤ
(ステップ13)
電極形成
(ステップ14)
イオン打込み
(ステップ15)
レジスト処理
(ステップ16)
露　光
(ステップ17)
現　像
(ステップ18)
エッチング
(ステップ19)
レジスト剥離
繰り返し